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NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

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COMPUTERIZED SUPPORT OF THE PRETRIAL CONFINEMENT DECISION-MAKING PROCESS IN THE MARINE CORPS

by

Charles William Campbell

March 1988

Thesis Advisor: David R. Henderson

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Computerized Support of the Pretrial Confinement Decision-Making Process in the Marine Corps

by

Charles William Campbell
Major, United States Marine Corps
B.S., Brigham Young University, 1974

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN INFORMATION SYSTEMS

from the

NAVAL POSTGRADUATE SCHOOL
March 1988

ABSTRACT

This thesis explored the feasibility of developing an expert system to assist Marine Commanding Officers in making accurate pretrial confinement decisions. The predictive value of a number of factors was investigated, based on interviews with those who make or review pretrial confinement decisions regularly and on a preliminary study of eight battalions at Camp Pendleton, California. The study revealed eight factors with predictive value. Rank, prior unauthorized absence, years of service, age, receipt of unit awards and positive page 11 entries manifested the types of association expected, based on the interviews. Seriousness of the charges showed a surprising inverse association with unauthorized absence, while GCT score suggested that those of average intelligence were less inclined to flee than those of either above average or below average intelligence. Findings were incorporated into a first-version prototype of the Pretrial Confinement Advisor (PCA) expert system using the M.1 Knowledge System Software Tool. Procedures for refinement and field testing of the prototype were recommended.

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I. INTRODUCTION

This thesis explores the development of an expert system to assist Marine Corps Commanding Officers in making more accurate pretrial confinement decisions.

A. BACKGROUND

When a Marine is accused of offenses serious enough to be referred to trial by Special Court-Martial, his Commanding Officer must determine whether he needs to be confined to ensure his presence at his trial. The Commanding Officer makes this pretrial confinement decision based on factors that he considers predictive of the Marine's inclination to run away. This would appear to be a problem tailor-made for an expert system application; it is narrow of scope, of moderate complexity, with a relatively small number of variables and a few, discrete possible outcomes. The difficulty lies in the fact that each Commander makes his pretrial confinement decisions differently. While there are broad areas of agreement among these "experts," there are also areas of sharp contention, greatly reducing the body of agreed-upon expert opinion that could be called "conventional wisdom."

The approach of this project was to build a knowledge base for the expert system based on conclusions from two sources: the body of "conventional wisdom" derived from the consensus of the experts interviewed, and the objective, demonstrable results of a study of predictive factors derived by the analysis of data from a sample of the units of interest.

B. RESEARCH QUESTIONS

The use of artificial intelligence, particularly expert systems, to assist in making what are considered to be subjective decisions has yet to be explored in the Marine Corps. First steps in a new direction should always be incremental, not becoming too theoretical or drifting too far from practical application. To achieve this, the project was guided by three relevant research questions:

1. From the information normally available to a Marine Corps Commanding Officer, can factors be identified that will enable him to predict whether or not an accused Marine will attempt to escape to avoid trial by court-martial?
2. Can such factors be incorporated into a rule-based expert system to advise Commanders on pretrial confinement decisions?
3. Can a method be devised to determine if the use of this expert system results in a net benefit to the units that employ it?

This thesis demonstrates that all three questions can be answered positively. The feasibility of the concept is shown by following one possible methodology through to development of a first-version prototype of the expert system sought.

C. SCOPE, LIMITATIONS, AND ASSUMPTIONS

1. Scope

At the outset of the project, it was recognized that, due to limits on time, funding and other factors, the scope of the investigation would be bounded by the following constraints:

- Data would be collected only from units based at Camp Pendleton, California.
- Only factors that could be known by a Commanding Officer at the time the pretrial decision is made would be studied.
- Development of the prototype would stop short of field testing.

As research progressed, however, it became apparent that further restrictions in the scope of the project were appropriate:

- Only infantry units of the First Marine Division were studied. The data strongly suggested that different types of units needed to be approached differently. In the aggregate, data from one type of unit masked informative relationships in the data from other types of units. Many potentially useful results came into focus when attention was restricted to infantry units.
- Only factors available from historical records were studied. Although a Commander can know many potentially relevant things about a Marine at the time the pretrial decision is made, only those factors recorded in official records were available for study after the fact.
- Only non-confinees were studied. Because there is no way to discriminate between confinees who would have fled and confinees who would have stayed, data concerning confined Marines was not useful to the study.

2. Limitations

Two significant limitations affected the study portion of the project:

- Time and Funding. Only five working days were available at Camp Pendleton for interviews and data gathering. This was the main constraint limiting the number of experts interviewed and the amount of data gathered.
- Reliance on Historical Data. Only factors that were recorded were available for study after the fact. This suggested that many potentially useful factors could not be considered.

The combination of these two limitations caused the most significant weaknesses in the study:

- The small number of factors that could be considered.
- The small size of the sample (in terms of numbers of Marines studied).

3. Assumptions

Despite the limitations and constraints, the project was able to proceed based on the following assumptions:

- The characteristics of the sample, despite its small size, approximate the characteristics of the target population: all Marine non-confinees charged with violations of the Uniform Code of Military Justice.
- A larger, less constrained study, as outlined in Chapter VI, Conclusions and Recommendations, will result in the development of a valid version 1 prototype.
- Field testing of the Version 1 prototype, under the conditions outlined in Chapter VI, Conclusions and Recommendations, will allow evaluation of the usefulness of the Pretrial Confinement Advisor expert system.

D. METHODOLOGY

Selected units were contacted months in advance; all expressed a willingness to cooperate in the study. A body of expert opinion was synthesized from interviews with individuals who make or review pretrial confinement decisions regularly. Case data for the study was gathered from eight selected Battalions at Camp Pendleton. The primary data source was the Service Record Books of accused Marines.

The data was numerically coded and entered into a MINITAB worksheet for evaluation. Although several methods of analysis were applied, the most informative proved to be the use of frequency tables, and the computation of means and phi coefficients.

The findings of the study and the results of the interviews were incorporated into the Pretrial Confinement Advisor expert system prototype, Version 0, using the M.1 Knowledge System Software Tool by Tecknowledge, Inc.

E. SUMMARY OF FINDINGS

Of the factors evaluated in the study, eight showed predictive value in determining the likelihood of unauthorized absence:

- Rank. Higher ranking individuals are less likely to flee than lower ranking individuals.

- Seriousness of the Charges. Surprisingly, Marines charged with more serious violations are less likely to flee than those charged with less serious violations.

- Prior Unauthorized Absence. Those with prior unauthorized absence are more likely to flee than those without.

- Years in Service. Marines in their second or greater enlistment are less likely to flee than those in their first enlistment.

- Age. Older Marines are less likely to flee than younger Marines.

- GCT (intelligence). Those of average intelligence are less likely to flee than those of either above average or below average intelligence.

- Unit Awards. Those who have received unit awards are less likely to flee than those who have not.

- Positive Page 11 Entries. Those with at least one laudatory page 11 entry are less likely to flee than those without.

Many of the factors considered by the experts to be predictive showed no significant association with the likelihood of unauthorized absence. Among these were:

- Prior Non-Judicial Punishments
- Marital Status
- Children
- Proximity of Home of Record to the Place of Duty

There are two possible explanations for findings of this type; either no association exists and the experts err when they rely upon these factors, or the study was too small and constrained to show the associations that exists. A larger, less constrained study will be required to either confirm or negate these conclusions.

F. ORGANIZATION OF THE THESIS

All concepts and terms appearing in this introduction are explained in greater detail in the chapters that follow.

1. Chapter II--Background

This chapter generally discusses pretrial confinement, including why pretrial confinement decisions are necessary and how they are made. The concept behind expert systems is discussed, and the M.1 Knowledge System Software Tool is introduced.

2. Chapter III--Methodology

This chapter describes how the data for the study was collected and the general philosophy of its evaluation. It outlines the problems encountered in the study, and discusses the prototyping method of software development.

3. Chapter IV--Evaluation of Data

This chapter describes how the data was quantified for automated manipulation and how it was examined. Evaluation of each factor is discussed in detail, and estimates of each factor's predictive value are given.

4. Chapter V--Development of the Prototype

This chapter describes the translation of the results of the data evaluation and the expert opinion gained through the interviews into knowledge-based rules for implementation into M.1.

5. Chapter VI--Conclusions and Recommendations

This chapter reexamines the three research questions in light of the progress made in the project. Recommendations concerning further work include:

- Conduct of a larger, less constrained study designed to avoid the difficulties encountered and documented in this thesis.

- Field testing of the next prototype version to determine the usefulness of Pretrial Confinement Advisor concept.

II. BACKGROUND

A. OVERVIEW

Answering the research questions posed in this thesis requires inquiry into diverse disciplines. The first subject of investigation is the military justice system, specifically pretrial confinement and how the pretrial confinement decision is made. Knowledge of expert systems and artificial intelligence is key, as well as familiarity with knowledge representation and ability with the particular program chosen to implement the findings of the pretrial confinement study. This chapter covers the background, literature, and theoretical framework related to these areas.

B. THE PRETRIAL CONFINEMENT PROBLEM

The question of pretrial confinement is one of many complicated issues arising from the unique character of the U. S. military justice system. The document that defines criminal conduct in the armed forces is the Uniform Code of Military Justice (UCMJ). Specific procedures and guidelines for the administration of justice under the UCMJ is contained in the Manual for Courts-Martial, 1984 (MCM). [Ref. 1]

When a Marine is accused of a violation of the UCMJ, his immediate Commanding Officer, usually a Battalion or

Squadron Commander, must make a determination as to whether he needs to be restrained to ensure his presence at his trial. Different types of restraint are described and authorized by the MCM:

> Pretrial restraint is moral or physical restraint on a person's liberty which is imposed before and during disposition of offenses. Pretrial restraint may consist of conditions on liberty, restriction in lieu of arrest, or confinement. [Ref.1:RCM 304(a)]

The most severe form of restraint is confinement.

> Pretrial confinement is physical restraint, imposed by order of competent authority, depriving a person of freedom pending disposition of charges. [Ref. 1:RCM 304(a)(4)]

The MCM stipulates that an accused Marine may be placed under restraint before disposition of charges only if probable cause exists:

> No person may be ordered into restraint before trial except for probable cause. Probable cause to order pretrial restraint exists when there is a reasonable belief that:
> 1. An offense triable by court-martial has been committed,
> 2. The person to be restrained committed it, and
> 3. The restraint ordered is required by the circumstances. [Ref. 1:RCM 304(c)]

Confinement, in particular, is considered required by the circumstances if:

> 1. It is foreseeable that the accused will not appear at trial, or
>
> 2. The accused will engage in serious criminal misconduct, and
>
> 3. Less severe forms of restraint are inadequate. [Ref. 1:RCM 305(h)(2)(B)]

A Commanding Officer must make the determination as to whether pretrial confinement is necessary based on the information available to him at the time. The MCM provides a basic set of factors that should be considered:

> A person should not be confined as a mere matter of convenience or expedience. Some of the factors which should be considered ... are:
> (1) the nature and circumstances of the offenses charged or suspected, including extenuating circumstances;
> (2) the weight of the evidence against the accused;
> (3) the accused's ties to the locale, including family, off duty employment, financial resources, and length of residence;
> (4) the accused's character and mental condition;
> (5) the accused's service record, including any record of previous misconduct;
> (6) the accused's record of appearance at or flight from other pretrial investigations, trials, and similar proceedings; and
> (7) the likelihood that the accused can and will commit further serious criminal misconduct if allowed to remain at liberty. [Ref. 1:RCM 305(h)(2)(B)]

This set of basic considerations is only a skeleton. It is generally felt that many other factors available to a Commanding Officer at the time of the pretrial confinement decision are relevant to the question of whether the accused is likely to flee to avoid prosecution. Virtually all Commanders and legal professionals interviewed during this study considered as relevant sets of factors that exceeded, in both scope and quantity, the criteria suggested in the MCM. Figure 1 contains some of the commonly suggested factors, not mentioned in the MCM, resulting from the interviews pursuant to this study.

Seriousness of the Charges
Types of Charges Pending
Previous Courts-Martial
Recent Reduction
Children
Family Living in Area
Own Home in Local Area
Awards and Achievements
Years in Service
CO's Recommendation
Surrendered or Apprehended
High School Graduate
Age
Distance of Home from Base
Socio-Economic Background
Security Clearance
Reputation as Troublemaker
Leadership of Staff NCO's
Proximity of Base to Major City
Pay Problems (Unit's Fault)
Alcohol/Drug Abuse
Non-U.S. Citizen
Second Job in Local Area
Maturity
Widowed Mother
Low Self-Esteem

History of Unauthorized Absence
Charges include Drug Offenses
Prior Non-Judicial Punishments
Marital Status
Children in School
Family in Government Quarters
Amount of Furniture Owned
Rank
Reputation for Reliability
Current Charges include UA
Race
College Courses Taken
Broken Home
GCT (Intelligence)
Importance of Job to Unit
Potential for Harassment
Bonds within the Unit
Serious Family Problems
Money Problems
Page 11 Entries
Poor Attitude toward Authority
Possession of Passport
Wanted for Civilian Charges
Receipt of "Dear John" Letter
Pregnancy of Wife/Girlfriend
Juvenile Police Record

Figure 1. List of Factors

Justice is administered in the armed forces by a hierarchy of tribunals. In order of increasing formality, they are:

- Non-Judicial Punishment (NJP). An administrative hearing by a Commanding Officer, NJP is restricted to considering minor offenses, and can impose very limited punishments. NJP may be offered by a Commander as a convenient alternative to a court-martial. Acceptance of NJP by the accused is voluntary.

- Summary Court-Martial (SCM). A military court composed of one officer of the accused's command. The officer (not an attorney) serves as military judge, prosecutor, and defense counsel. Procedures and rules of evidence, while informal, must conform to higher standards than in NJP. A Summary Court-Martial considers more serious offenses than may be disposed of at NJP. The SCM is offered to the accused as a convenient alternative to a more formal court-martial. It can award greater punishment than NJP (up to 30 days confinement at hard labor, for example). Acceptance of a SCM by an accused is voluntary.

- Special Court-Martial (SPCM). A full judicial proceeding presided over by a judge. The accused is assigned a judge-advocate (military lawyer) as his defense counsel, and the prosecutor is usually a lawyer also. Procedures are formal and the military rules of evidence are strictly adhered to. An SPCM can award punishments of up to six months confinement at hard labor, six months forfeiture of all pay and allowances, and a Bad Conduct Discharge from the military service. Participation is not voluntary.

- General Court-Martial (GCM). The most formal military court, convened by a General Officer to consider serious violations of the UCMJ. Can award any punishment authorized by law, including death and life imprisonment.

The MCM empowers Commanding Officers to order the pretrial confinement of Marines accused of offenses triable by Court-Martial. [Ref. 1:RCM 304(c)] Technically, this means he must consider the offenses to be appropriate for either SCM, SPCM, or GCM disposition. In practice, however, offenses dealt with at SCM are not considered serious enough to justify pretrial confinement. When a Commander places a Marine in pretrial confinement, then, it is assumed that he anticipates referring the charges to trial by SPCM or requesting referral to GCM.

It should be stressed that the decision to confine or not to confine is solely the realm of the Commander. Although some published guidelines exist, they are advisory in nature and do not limit the Commander's discretion. Each Commanding Officer has his unique set of criteria he deems relevant, and each one makes his pretrial confinement decisions differently, with very little to restrict him.

In the mid 1970's Military Magistrates were formally established to review all pretrial confinements and screen out those that were grossly inappropriate. When a Commander decides to place a Marine in pretrial confinement, he must justify the decision to the Military Magistrate who, if not satisfied, has the authority to order the Marine released. This latter action, however, rarely occurs. During an interview in December, 1987, the Military Magistrate at Camp Pendleton, California related that, of the hundreds of confinement justifications he has reviewed during his tenure, he considered only two to be inappropriate (he ordered the release of both Marines, and both immediately fled military control to avoid prosecution). Of the eight Commanders and key legal officers interviewed during the study, none considered the Military Magistrate a significant factor in limiting the discretion of a Commanding Officer to confine an accused Marine.

Errors in the pretrial confinement decision process are costly to the government. If a Commander confines a Marine who, if not confined, would remain with his unit and be present for trial as ordered, the government has lost:

- The cost in manpower and effort of performing the confinement function; transportation, escorts, inventory of personal effects, required weekly visits, etc. Although the Marine is confined, his unit is still responsible for his welfare and maintenance.
- The allocated cost of maintaining the accused in the confinement facility (some fraction of the total operating cost of operating the facility).
- The value of the accused's services in the unit during the confinement period.

If, on the other hand, the Commander decides not to confine a Marine who subsequently runs away to avoid prosecution, the government suffers:

- The waste of all effort expended to that point to bring the case to trial.
- Delay in the administration of justice, and loss of deterrent effect of expeditious resolution of charges.
- The eventual cost of recapture, security and transportation back to the unit.

Because the latter mistake is more visible, and the costs more quantifiable and apparent, it is generally felt that Commanders are typically more willing to err on the side of strictness than leniency; that is, when in doubt, they tend to confine.

To summarize, the Commanding Officer of an accused Marine makes the decision to either trust him to remain with his unit or confine him to ensure his presence at trial. The set of criteria used to make this decision is unique to each Commander, and consists of some subset of the many elements of information available at the time. These elements of information are the subject of this study.

C. EXPERT SYSTEMS

1. Definition of an Expert System

Expert systems belong to a class of computer programs known as Artificial Intelligence (AI). Simply stated, artificial intelligence is behavior, by a computer program, which would be considered "intelligent" if observed in humans. [Ref. 2:lectures 3 & 4] To describe such behavior, we might use such words as "thinking" or "reasoning." An Expert System is a bounded artificial intelligence program; it is created to solve problems in a particular, limited domain. [Ref. 3:p. 21]

> A subset of that vague genus of computer science dubbed artificial intelligence (AI), an expert system seems to "reason" about the real world by mimicking the human cognitive process, using logistical relationships that occasionally border on the metaphysical. Rather than merely processing data, the expert system processes symbolic representations of reality within a structure that attempts to replicate the analytical processes followed by a human expert in a particular field. [Ref. 4:p. v]

The British Computer Society's Committee of the Specialist Group on Expert Systems officially defined an expert system in this way:

> An expert system is regarded as the embodiment within a computer of a knowledge-based component from an expert skill in such a form that the system can offer intelligent advice or take an intelligent decision about a processing function. A desirable additional characteristic, which many would consider fundamental, is the capability of the system, on demand, to justify its own line of reasoning in a manner directly intelligible to the engineer. [Ref. 5:p. 1]

However defined, expert systems are computer programs that can do specialized, narrowly-defined tasks as well, or better, than a human expert. [Ref. 2:lectures 3 & 4] They are sometimes called knowledge-based systems because their data is organized into "chunks" of knowledge, of which more will be said later.

Expert systems are created by capturing the analytical processes, methods, and rules-of-thumb used by experts in a particular field, and translating these into a computer program which can apply them to solve problems.

> Some people package their expertise in books. But developing an expert system is often a better way to package your expertise. You can enter your knowledge in the form of rules into the expert system; the expert system can then communicate with a client having a problem, reason with these stored rules, and then give the client advice and even explain its reasoning. [Ref. 6: pp. 1-2]

Expert systems differ considerably from conventional programs; while a conventional program is deterministic, following the same sequence of steps for every problem it confronts, the expert system traces a unique decision tree each time it is presented with a new goal. While a conventional program follows established mathematical rules, the expert system does symbolic processing based on heuristic reasoning. [Ref. 4:p. 7]

Expert systems in general are characterized by the following five attributes:

1. A Knowledge Base. The information an expert system draws upon is highly processed, and organized in a manner thought to model the way humans remember things.

2. Reasoning Capacity. The expert system manipulates and uses its knowledge in a manner thought to replicate the way humans think and reason.

3. System-User Dialogue. The expert system gains the knowledge it does not have, but needs, by asking questions of the user. Conversely, the user may ask questions of the expert system as well. The system performs its function through this dialogue, which continues until its goal is met.

4. Uncertainty. Much of human reasoning is qualitative and imprecise, relying on feelings, approximations, and different levels and shades of certainty. We are "almost positive" the group will arrive on time, or we "strongly doubt" Pamela will like the taste of Elk meat. Expert systems mimic this human characteristic by assigning facts a certainty factor (cf) based on the expertise programmed into them.

5. Explanation Capability. An expert system has the ability to explain or represent its reasoning process in a way understandable and useful to the user. [Ref. 6:p. 16]

2. Elements of an Expert System

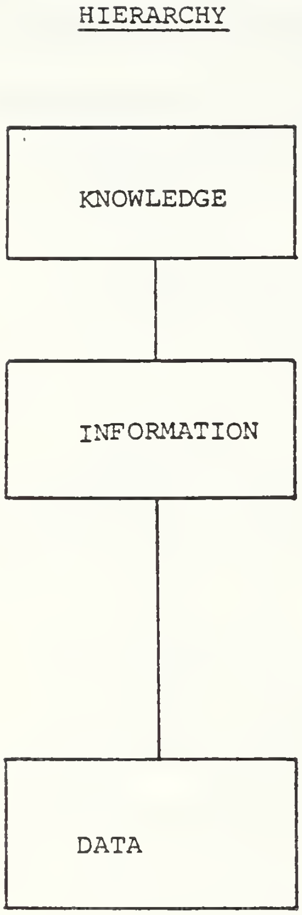
There are three primary elements of an expert system: the knowledge base, the inference engine, and the user interface. [Ref. 4:p. 17]

a. Knowledge Base

Knowledge can be thought of as information that is processed and interpreted to such a high degree as to be a ready basis for decision-making. [Ref. 6:p. 3] A useful way to think of knowledge is as the top of an information hierarchy (Figure 2). Data consists of elements of fact, unorganized and unstructured. Information is data organized into a more useful form, but still requiring knowledge to interpret. Conventional processing deals in information, which a knowledgeable user must translate. Knowledge is interpreted information. No further processing is required. [Ref. 6:p. 3]

Based on these definitions, Figure 3 displays who-does-what in three different type of processing systems. A rudimentary data retrieval system (top) leaves most of the processing to the user. A conventional data processing system (center) presents the user with useful information which he still must interpret. The knowledge-based expert system does all the processing required to provide the user with a finished product, upon which he can base a knowledgeable decision. [Ref. 6:p. 4]

Key to the ability of an expert system to model the reasoning of a human expert is its capacity to capture his methods (knowledge) in its store of facts and procedures (knowledge base). Of the many ways knowledge may be



EXAMPLE

Oldest Marine - MGySgt Sparks (68)
Youngest Marine - 2dLt Parker (22)

Name	Age
Major C. W. McCall	42
Capt J. Breshers	29
2dLt P. Parker	22
MGySgt Sparks	68
.	.
.	.
.	.

560829356,42,173942689,29,
112460142,22,178472111,68,
332804122,27,785064729,31,

Figure 2. Information Hierarchy

System	Source	Done by Machine	Output	Done by User
Data Retrieval System	Data Files	Data Processing	Data	-Information Processing -Knowledge Processing -Decision-Making
Conventional Data Processing System	Data base	Information Processing	Information	-Knowledge Processing -Decision-Making
Expert System	Knowledge base	Knowledge Processing	Knowledge	Decision-making

Figure 3. Comparison of Who-Does-What

represented in expert systems, three methods predominate: [Ref. 2:lectures 3 & 4]

1. Semantic Nets. A semantic net is a graphic way of representing knowledge in terms of nodes and links (Figure 4). Nodes, shown as circles on the diagram, can represent objects (house, man, hat), concepts (pride, home, length), or descriptors (green, happy, forceful). Links, on the other hand, describe relationships between the nodes (is, has, belongs to, is responsible for). [Ref. 6:p. 5] Figure 4 displays a partial semantic net to illustrate its structure. At the center of the network is the accused Marine, the focus of our interest. The diagram tells us that an accused Marine will have a service record book which can be expected to contain three elements of relevant information: his disciplinary record, proficiency and conduct marks, and record of emergency data. We also see that the accused reports to a Commanding Officer, from whom we can gain an opinion as to the accused's general reliability. Lastly we see that the accused will be of a certain rank. Semantic nets are intuitively appealing because they closely model the way human remember facts and relationships, and thus seem "natural."

2. Frames. Frames are similar to semantic nets in that they capture objects, concepts, and their relationships. They differ from semantic nets in their format, which is columnar rather than diagrammatic (Figure 5). In simple terms, a frame is analogous to a "chunk" of knowledge which a human will call up in memory when faced with a certain situation or problem. [Ref. 6:p. 5]

3. Rules. Rules are the most common way of representing knowledge in expert systems. The popularity of this method may stem from its undeniable resemblance to the basic If-Then programming structure. The general syntax of a rule-type knowledge base is:

    IF (one or more premise clauses connected by AND, OR, or NOT)
    THEN (one or more conclusions connected by AND, OR, or NOT)

   When a rule executes in an expert system knowledge base, the premise is tested to see if it is true. If so, the conclusion is placed in the system's working memory. [Ref. 2:lectures 3 & 4] One of the

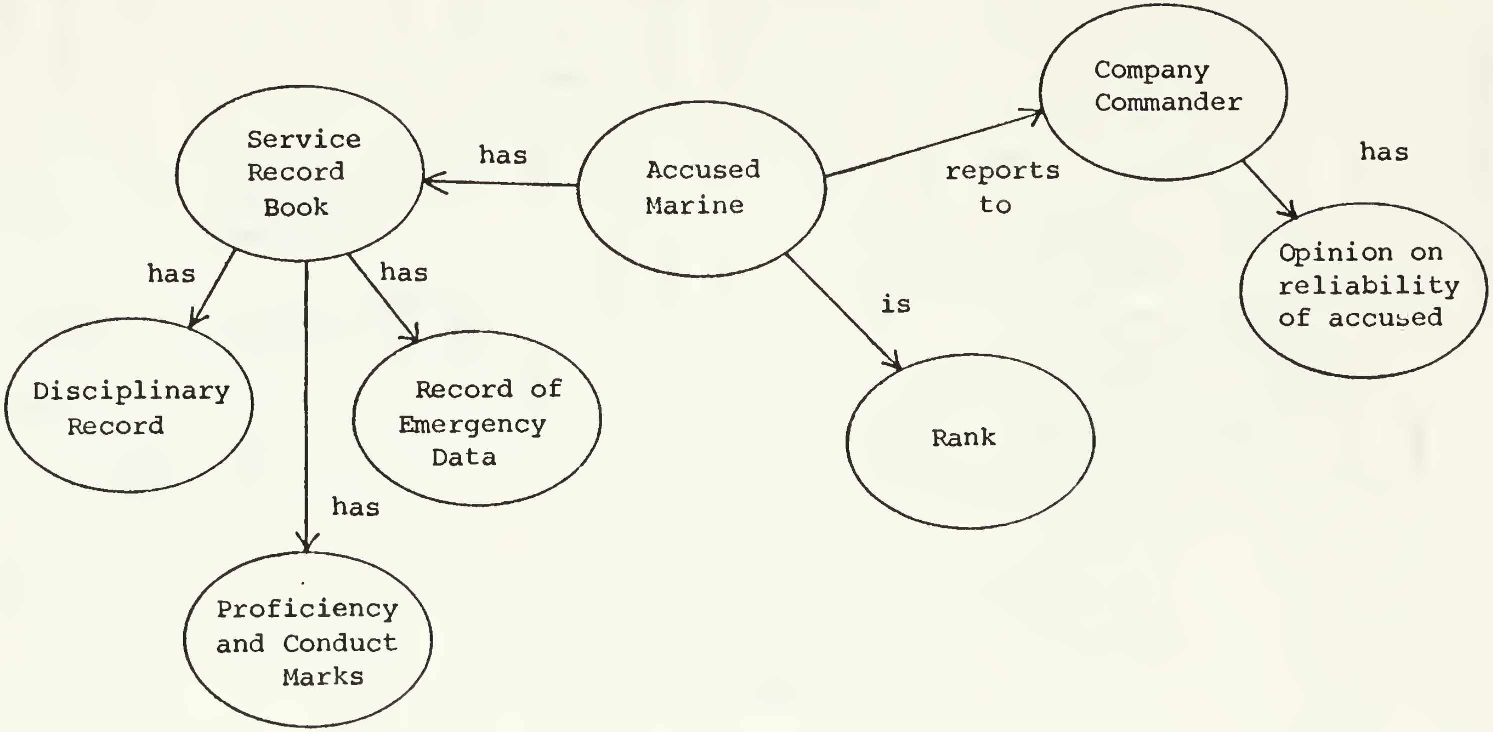


Figure 4. Semantic Network

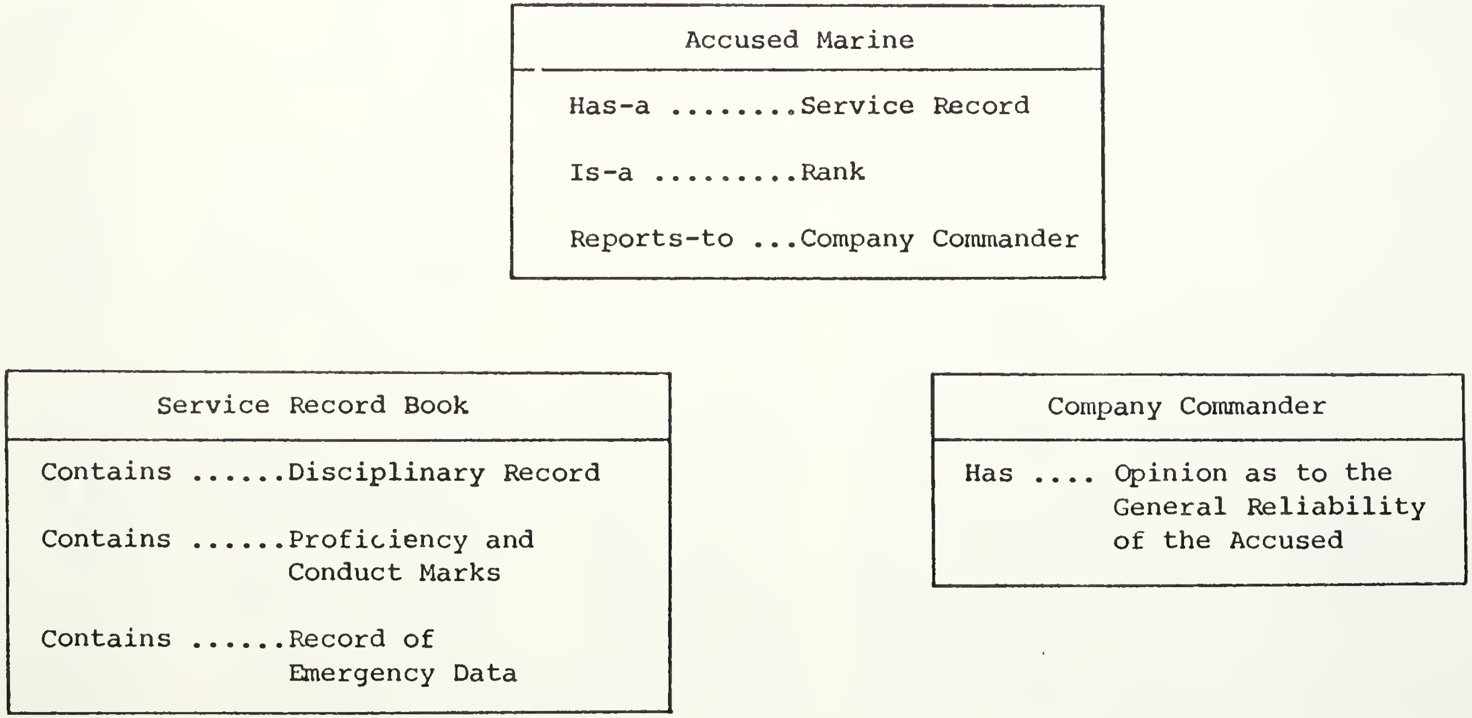

Accused Marine
Has-a ....Service Record
Is-a ....Rank
Reports-to ...Company Commander
Service Record Book
Contains ......Disciplinary Record
Contains ......Proficiency and Conduct Marks
Contains ......Record of Emergency Data
Company Commander
Has .... Opinion as to the General Reliability of the Accused

Figure 5. Frames

advantages of this IF-THEN structure is its flexibility. Figure 6 illustrates a few of the many ways rules can be configured to represent different types of knowledge. [Ref. 2:lectures 3 & 4]

b. Inference Engine

The ability of an expert system to "reason" is based upon the process of inference. Inference is the drawing of conclusions about the unknown from what is known. John Dewey defined it in this way:

> The process of arriving at an idea of what is absent on the basis of what is at hand is inference. Every inference, just because it goes beyond the ascertained and known facts, which are either given by observation or by recollection of prior knowledge, involves a jump from the known into the unknown. [Ref. 4:p. 12]

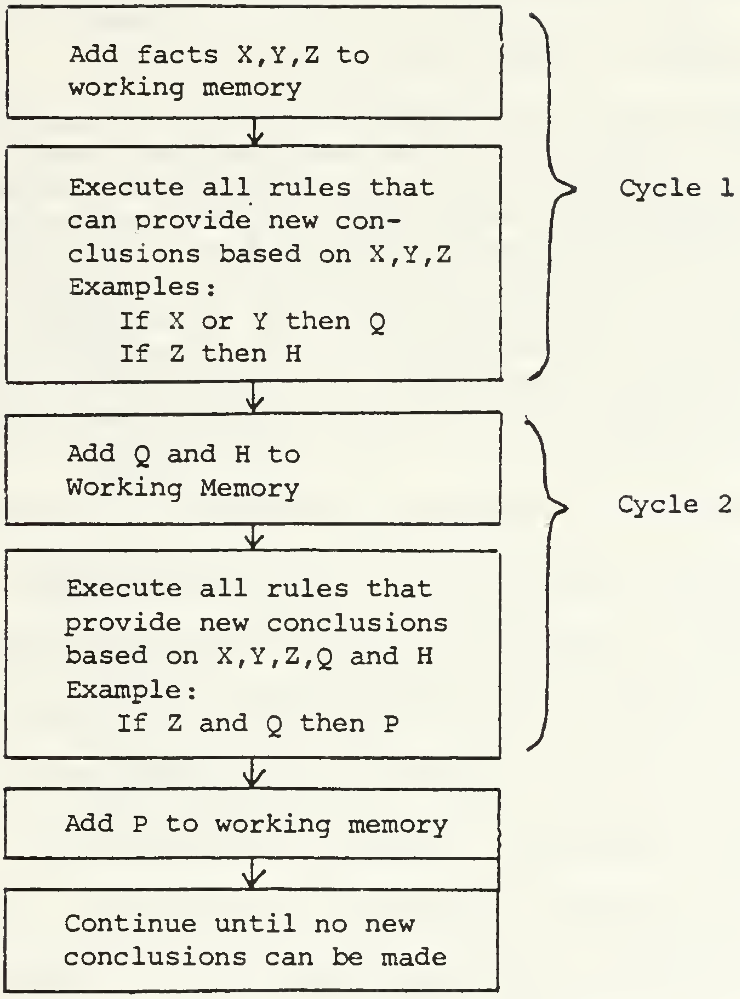
An expert system executes the inference process by searching the relationships among the rules in its knowledge base according to some predetermined strategy. Four strategies that have been used in expert systems are forward chaining, backward chaining, relaxation and cyclicity. Relaxation (the organizing of a large number of potential conclusions by gradually eliminating those that violate given problem constraints) and cyclicity (based on the scientific method of iteratively forming and testing hypotheses) are rare and, as they are not germane to this study, they will not be discussed here. [Ref. 2:lecture 3]

Forward Chaining starts with the given facts and works forward, executing all appropriate rules until the final conclusions are reached. Figure 7 illustrates the cyclical nature of forward chaining. This approach is

Type of Knowledge	Examples
Definitional	IF the accused's service record book contains a valid, current enlistment contract THEN the accused is a service member.
Heuristic	IF the accused has shoulder-length hair or a beard THEN the accused is not an active duty Marine.
Procedural	IF current_year = D AND year_of_birth = B THEN Age = D - B (+ or - 1)
Control	IF rank of the accused is not found in working memory THEN display "What is the accused's rank?"
Instantiation	IF SSN_Prefix = 560 THEN Home_State = California
Uncertainty	IF MCI_Courses is greater than 5 THEN Years_in_Service is greater than 1 with a certainty factor of 80.*

* Certainty Factors (cf) refer to the degree of certainty with which a clause may be assumed to be true.

Figure 6. Types of Knowledge Represented by Rules



Add facts X,Y,Z to working memory

Execute all rules that can provide new conclusions based on X,Y,Z
Examples:
If X or Y then Q
If Z then H

Add Q and H to Working Memory

Execute all rules that provide new conclusions based on X,Y,Z,Q and H
Example:
If Z and Q then P

Add P to working memory

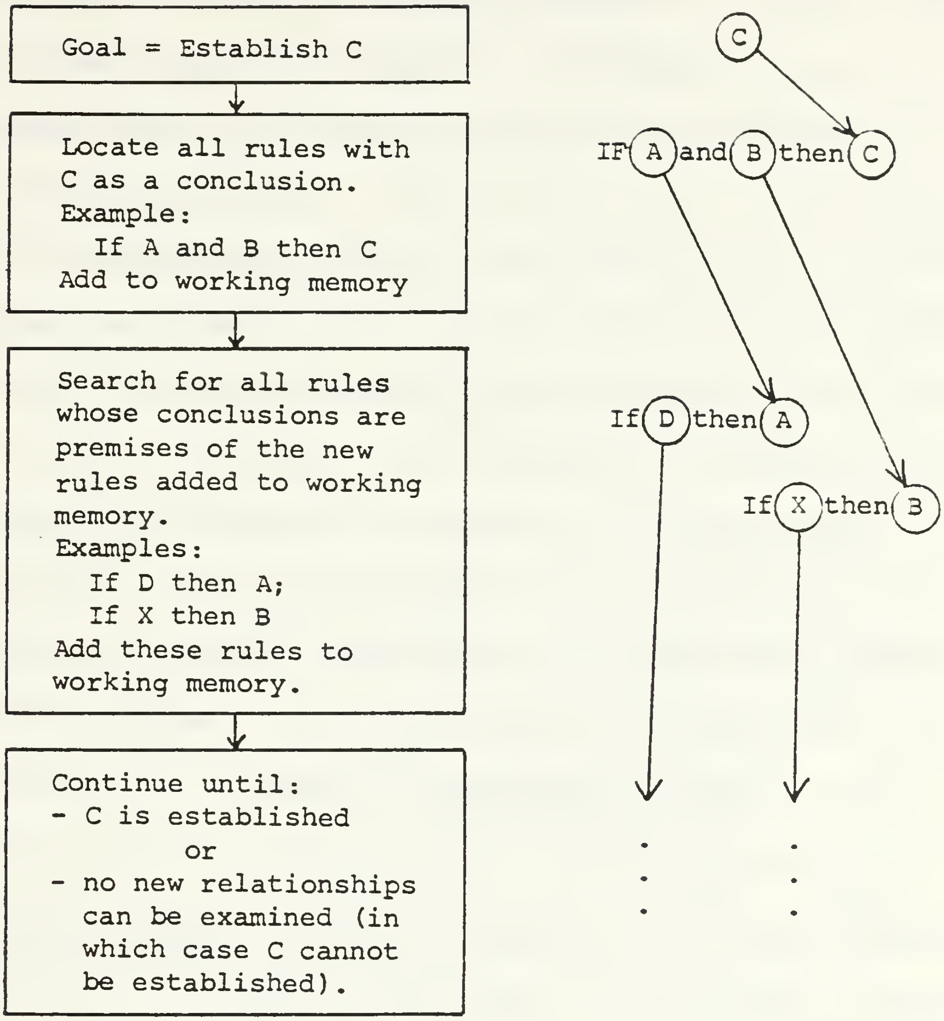
Continue until no new conclusions can be made

Figure 7. Forward Chaining

called "data driven" because it begins with given data and exhaustively searches every corner of the knowledge base according to the new data that is added to the working memory during each cycle. [Ref. 5:p. 183] It is not the preferred strategy because, due to its comprehensive nature, it expends time and effort in establishing conclusions that are of no interest to the user:

> It's a method that will eventually produce answers, even if it means a value has to be provided for each and every variable before you get the specific answer you want. It's just that some people might feel uneasy about a method that seems to proceed with complete disregard for the network through which it's proceeding or the eventual goals you might wish to achieve. Not so much a method, it's rather more like some kind of primordial sludge which oozes through the network of nodes on the basis of: "this bit looks interesting, let's look at that next." [Ref. 5:p. 138]

Backward Chaining is referred to as "Goal Driven" because it starts with a particular target conclusion that it wishes to examine and selectively searches the knowledge base for relevant rules that will help it reach its goal. Figure 8 illustrates the steps executed in this approach. Backward chaining is characterized by focused, purposeful execution. It is the most common inference strategy because of its efficient, mission-oriented nature. The user will quickly be apprised of whether his target conclusion is correct or incorrect, with little time or effort wasted. Backward chaining may not always be the most efficient method of searching a knowledge base, however. When there is no



Goal = Establish C

Locate all rules with C as a conclusion.
Example:
If A and B then C
Add to working memory

Search for all rules whose conclusions are premises of the new rules added to working memory.
Examples:
If D then A;
If X then B
Add these rules to working memory.

Continue until:
- C is established
or
- no new relationships can be examined (in which case C cannot be established).

Figure 8. Backward Chaining

particular goal sought for, but rather the desire is to see what conclusions can be reached from a given set of facts, Forward chaining may be more appropriate.

An essential capability of the inference engine in an expert system is the ability to accommodate uncertainty. Since inexactness, approximation and missing data are part of the human expert's environment, the expert system must be able to function in disorder, as well. It does this by assigning confidence factors (cf) to both conclusions and premises in its knowledge base. A confidence factor is a measure of certainty on a scale of -100 (No, with absolute certainty) to +100 (Yes, with absolute certainty). A confidence factor of 0 indicates there is no evidence either way. For example the rule

```
    IF      Time_in_Service >= 4 and
            Reductions_in_Rank = 0

    THEN    Rank =  E-4 cf 80
```

expresses the rule-of-thumb that if a Marine has been in the service four years or more and has not been reduced in rank during disciplinary action, he is "probably" (cf 80) a Corporal. Assumptions can also be built into the knowledge base. For example, the rule

```
    IF      Weight_Control = unknown ( that is, cf between
           -20 and +20 )

    THEN    Weight_Control = No
```

captures the policy that if whether a Marine is participating in the weight control program is unknown, it will be assumed he is not. [Ref. 2:lectures 3 & 4]

Combinations of confidence factors in premises and conclusions yield the results outlined in Figure 9.

c. User Interface

The user interface is the combination of all the ways in which the expert system and the user communicate with each other. Although there may be as many interface formats as there are systems, one universal characteristic is the Dialogue--the exchange of questions and answers during system use. A useful illustration is the backward chaining inference process shown in Figure 8. If, after a given number of cycles, the system needed to establish M in order to establish C (the goal conclusion), and there was no evidence of M in the knowledge base or working memory, the system dialogue feature would ask the user for the value of M. Suppose M were a variable indicating the marital status of a Marine and could hold the values YES or NO. The user might see the following on the monitor:

```
Is the accused married?
(record of emergency data behind pg.12 or
check for dependency applications on doc-
ument side of SRB.)

       1. Yes
       2. No
```

After the user responds, the value of M is added to working memory, and backward chaining continues as before. The

Circumstance	Rule	Example
Uncertainty in a premise	Conclusion takes on the certainty factor of the premise	IF HS_grad = yes THEN assignment = clerk (If HS_grad = yes cf 50, conclusion is assignment = clerk cf 50)
Conjunctive Premise (connected by AND)	Conclusion takes on the certainty factor of the weakest premise clause	IF incompetent = yes AND drug_use = yes THEN discharge = yes (If incompetent = yes cf 30 and drug_use = yes cf 60, then the conclusion is discharge = yes cf 30.)
Disjunctive Premise (connected by OR)	Interprited as two separate rules	If only one rule applies, see uncertainty in premise above. If two or more rules apply, see accumulating certainty below.
Uncertainty in both Premise and Conclusion	$\frac{cf(conclusion)*cf(premise)}{100}$	IF GCT is greater than 110 THEN assignment = Squad Leader cf 40 (If GCT is greater than 110 cf 80, then assignment = Squad Leader cf 32)
Accumulating Uncertainty (two or more rules conclude about the same fact)	(cf1+(cf2*(100-cf1)))	Rule 1: IF weather = storm THEN action = cancel cf 50 Rule 2: IF Power = out THEN action = cancel cf 25 (If weather = storm and Power = out, then cancel is made increasingly certain (cf 63))

Figure 9. Rules for the Use of Certainty Factors

dialogue feature also permits the user to query the system, albeit in limited ways. Common among expert systems is an explanation capability which allows the user to question the system's reasoning process. Consider the following sequence:

Expert System	Does the accused's immediate family or next or kin live within 3 hours' drive of the unit location? 1. Yes 2. No
User	Why?
Expert System	Studies have demonstrated that Marines with relatives nearby are less likely to flee to avoid prosecution. Although the reason is not known, it is thought that the Marine may perceive the probability of recapture to be high.

Because operation of the expert system involves the same sort of mutual questioning and responding that might characterize an interview with a human expert, the period of user-system interface is commonly known as a "consultation."

3. State of Expert System Technology

Expert systems are still considered an emerging technology. Although the future possibilities that can be imagined are innumerable and fascinating, current expert system applications are still rather limited. The following points summarize the current state-of-the-art in expert system technology:

- Scope is limited to a narrow, well defined area of expertise (Geology, Medicine, etc.).
- Expert system behavior is best in the mainstream of a discipline, where there is general consensus among experts. Behavior is more erratic at the "boundaries" where there may be little consensus.
- Knowledge representation language is still in its infancy; awkward, cumbersome, and showing little finesse.
- Interfaces, also, are still underdeveloped.
- Explanation capabilities are limited to foreseeable queries. Unanticipated queries may not be answerable by the system.
- A knowledge base can capture and hold the expertise of only one discipline at a time. This is because only rules that are related interact with each other during a consultation. Until inference engines become capable of pursuing more than one line of reasoning at a time, there will be no advantage to combining autonomous sets of rules in the same knowledge base.

4. Expert System Development

Traditional software development proceeds through a step-by-step lifecycle known as the classic "waterfall" model [Ref. 7:p. 20] or "Modular Design." [Ref. 8:p. 736] Artificial intelligence programs--including expert systems--and decision support systems do not respond well to the classic, lock-step approach because their structure is ill-defined at the outset of development, and only becomes clearer as design progresses.

> Due to the inherent nature of the complexity and ill-structuredness of the domain knowledge represented in a DSS, the DSS designer cannot--and should not--be required to have a complete understanding of the users' needs prior to the design and implementation process. Rather he/she should expect that the emergence of unanticipated informational needs is a continuing part of the design and development effort. [Ref.8:p. 736]

The alternative development method that has proven effective in the design of expert systems is known as prototyping. An adaptive design strategy, prototyping initiates development by producing a quick working model that contains the basic features and meets the minimum functional requirements. This "version 0" is given to the user to evaluate. Based on the user's suggestions, the developer produces an enhanced "version 1," which is delivered to the user for further evaluation, and so on until a satisfactory model is produced. [Ref. 8:p. 737]

The prototyping design methodology was applied in implementing the results of the pretrial confinement study into an expert system.

D. M.1

The expert system development program chosen to implement the findings of the study on pretrial confinement is the M.1 Knowledge System Software Tool, version 2.0 by Teknowledge Inc. M.1 has the capacity to accommodate up to 2,500 rules in its knowledge base, and is written in the C programming language. Although limited in some respects, M.1 has many characteristics that suit it to this particular application. A few of these are discussed below. [Ref. 9: pp. 1.1-1.20]

1. Problem Characteristics. M.1 is designed to implement very narrowly defined problems. This limitation, however, reflects the state of the art generally. Suitability of the problem for implementation in M.1 can be judged on the basis of the following criteria:

- Time. The problem should be one that a human expert should be able to solve in 30 minutes or so.

- Described in Words. The problem cannot require physical contact, or use of the senses such as sight or touch. The problem must be solvable through the use of language alone. If the problem can be described and solved over the telephone, it will meet this criterion.

- Judgmental Reasoning. Traditional programming is more effective for problems that involve many calculations or formal analysis. The strength of an expert system lies in its ability to handle ill-defined, unstructured concepts and reason with them.

- Subproblems. The problem can be broken down into a few identifiable, discrete subproblems. This is a limit on the complexity of the problem.

- Solutions. For each subproblem, there should be only a few dozen possible solutions. This is a second limit on the complexity of the problem.

2. Knowledge Base. M.1 is a rule-based system; it conducts inference activity using knowledge represented in the form of rules and facts. Programming the knowledge base involves using M.1 knowledge representation language to create rules in a standard non-document file with a word processor. The M.1 knowledge representation language accommodates such features as symbolic variables and certainty factors.

3. Inference Engine. The fundamental inference strategy in M.1 is that of backward chaining. It also has a controlled forward chaining capability that can be invoked through a set of high priority goals. This gives the system the capability of interrupting the backward chaining process to pursue a task triggered by one or a combination of conclusions in the working memory.

4. User Dialogue. The consultation takes place in English using question-answer format with, usually, one-keystroke responses. A window option allows the user to view the rules as they are being executed, and will allow him to vary the speed of execution to his reading speed.

5. Other Features. M.1 accommodates the use of proper-response menus (guiding the user as to how to respond), will check every user response to ensure it fits the set of preprogrammed legal values, and will allow the programmer to generate alternative questions. This last feature is especially useful in simplifying the query-answer process. When M.1 seeks an answer from the user (for instance, the value of a variable R representing rank), its generic request will be:

What is the value of R?

The M.1 programmer is allowed to substitute a more understandable question, such as

What rank does the accused hold?

1. Private
2. PFC
3. Lance Corporal
4. Corporal
5. Sergeant

These and other characteristics highlight M.1's suitability for accommodating the small size, narrow scope, and inherent complexity of the pretrial confinement expert system.

III. METHODOLOGY

Development of the Pretrial Confinement Advisor proceeded in three phases. Phase one was the collection of data. This phase focused on the factors that the people who make the pretrial confinement decisions--the "experts"--consider important. Phase two was the analysis of the data collected to determine the validity and weight of each factor. Phase three was the development of a first-version prototype, incorporating the results of phase two into an expert system. Each of these phases is discussed below.

A. COLLECTION OF DATA

Data were collected from eight Battalions at Marine Corps Base, Camp Pendleton, California during the period 16-24 December 1987. Seven of the eight Battalions were infantry Battalions of the First Marine Division. The remaining Battalion was a support unit containing students who were relatively new to the Marine Corps. This Battalion was included in the data collection at the suggestion of a knowledgeable judge-advocate who made a convincing argument that the unique situation of new Marines, recently graduated from boot camp and coping with their first challenges in the "real" Marine Corps, should not be overlooked.

1. Criteria Input

The first two days of the data gathering effort were spent in interviews and discussions with officers involved in pretrial confinement decisions at Camp Pendleton; the Military Justice Officer at the Base Office of the Staff Judge-Advocate (OSJA), the Military Magistrate for all units at Camp Pendleton, trial and defense lawyers of the Base OSJA, and some of the Commanders, Executive Officers, and Legal Officers of the units to be visited. These discussions resulted in the first-cut list of candidate factors previously shown as Figure 1 in Chapter II, and duplicated here for convenience as Figure 10.

2. Selection of Criteria

It was apparent at the outset of the project that, due to time and funding constraints, the data for this initial prototyping effort would have to come from historical sources. In retrospect, this proved to be the most constraining element of the entire undertaking. Much more potentially useful data could have been gathered using ongoing surveys, over six months or more, to capture data at the time the pretrial decisions were being made, but this option was not available. The original list of factors, then, needed to be trimmed down to those that could be reasonably gleaned from historical records.

The principal historical record for each enlisted Marine is his Service Record Book (SRB) which contains a

Seriousness of the Charges
Types of Charges Pending
Previous Courts-Martial
Recent Reduction
Children
Family Living in Area
Own Home in Local Area
Awards and Achievements
Years in Service
CO's Recommendation
Surrendered or Apprehended
High School Graduate
Age
Distance of Home from Base
Socio-Economic Background
Security Clearance
Reputation as Troublemaker
Leadership of Staff NCO's
Proximity of Base to Major City
Pay Problems (Unit's Fault)
Alcohol/Drug Abuse
Non-U.S. Citizen
Second Job in Local Area
Maturity
Widowed Mother
Low Self-Esteem

History of Unauthorized Absence
Charges include Drug Offenses
Prior Non-Judicial Punishments
Marital Status
Children in School
Family in Government Quarters
Amount of Furniture Owned
Rank
Reputation for Reliability
Current Charges include UA
Race
College Courses Taken
Broken Home
GCT (Intelligence)
Importance of Job to Unit
Potential for Harassment
Bonds within the Unit
Serious Family Problems
Money Problems
Page 11 Entries
Poor Attitude toward Authority
Possession of Passport
Wanted for Civilian Charges
Receipt of "Dear John" Letter
Pregnancy of Wife/Girlfriend
Juvenile Police Record

Figure 10. List of Factors

variety of entries intended to be permanent. This is as opposed to training records, which are designed to hold the current state of cyclical or periodic training. Of particular interest in the SRB are documents containing the Marine's disciplinary history (pages 12 and 13) and personal information (Visual Audit Sheet, Record of Emergency Data, and others to be discussed later in this chapter). Other documents of interest are the Unit Punishment Book (UPB) and Confinement Orders. The UPB is created when a Marine is first accused of a violation of the UCMJ, before any legal action, judicial or non-judicial, is taken. It contains the specification of charges and their disposition at each level of command. A Confinement Order is created when a Marine is placed into confinement, either by sentence of a court-martial or while awaiting trial (pretrial confinement). It contains information about the confinement itself: date and time, place of confinement, basis (sentence or pretrial), Commanding Officer ordering the confinement, etc. Individual unit legal officers typically keep unofficial records for their own information. Although some of these "memorandum records" contained potentially useful data, they were not used in the study because their subject matter and format were not uniform across the units studied.

A second constraint, following the need to use historical records, was that of volume. As the time available for gathering data was limited, the number of factors considered had to be manageable in order to allow enough individuals to be studied. Not knowing beforehand how difficult or time consuming the process would be, a best-guess estimate was made and the number of factors was arbitrarily set at 35.

The selection process, then, was one of:

- Eliminating factors which could not be determined from historical sources, and
- Subjectively screening the remaining factors for relevance to reduce the number to 35.

The result of this selection process was the list of factors shown in Figure 11.

3. Data Entry Sheet

To expedite the gathering of the 35 identified data elements, I grouped the factors according to historical source and placed them on a single data entry sheet (see Figure 12).

The first grouping contained information to be collected from the UPB and other non-SRB sources. This grouping also contained non-factor information for identification purposes, such as name and social security number. As data gathering progressed, it became apparent that all of this information was available in the SRB. Consequently, use of the UPB was eventually dropped.

The second grouping contained factors that could be extracted from pages 12 and 13 of the SRB (disciplinary history). Page 12 is a record of non-judicial punishments

1. Data Entry Sheet Number
2. Type of Unit
3. Unit Designation
4. Rank
5. Type of Charges
6. Seriousness of Charges
7. Confined
8. Surrendered or Apprehended
9. Fled to Avoid Trial
10. Previous UA
11. Previous NJP
12. Court-Martial Convictions
13. Reductions in Rank
14. Years in Service
15. Population Group
16. Age
17. Marital Status
18. Children
19. GCT (Intelligence)
20. Education Level
21. Family in local area
22. Children in School
23. Family in Quarters
24. Parents Living Apart
25. Proximity of Home to Base
26. Unit Awards
27. Personal Awards
28. Good Conduct Medals
29. Meritorious Masts
30. Letters of Appreciation
31. Positive Page 11 Entries
32. Negative Page 11 Entries
33. MCI Course Completed
34. Average Proficiency Mark
35. Average Conduct Mark

Figure 11. Final Data Element List

Data Entry Sheet

UPB, Conf Order, IRO
Unit_____________ Name____________________SSN __________________
Rank_____________ Date of UPB ____________
Charges:____
____
____
____
____
Confined___ Date_________ Current chgs include UA_______________
Surr or App______________

Page 12
Previous specs UA___________ Previous NJPs_______________________
CM convictions _____________ Reductions resulting________________

VAS
Active duty base date___________________pop grp__________________
DOB ____________Married_________childeren________GT/GCT__________
Ed level_______________ Weight Control _____________

RED
Imm fam in area_____________ Kids in school______________________
fam in qtrs_________________ par w/ sep addr_____________________
state of NOK________________

Page 9
Unit awards___________personal awards_____________GCM____________
merit mast____________ltr of appreciation____________

Page 11
* positive entries____________* negative entries____________

Page 8a
* MCI course completed _______________

Page 4
ave pro marks ___________ ave con marks_____________

Figure 12. Data Entry Sheet

and of unauthorized absence. Page 13 is a record of court-martial convictions.

The third grouping contained factors that could be extracted from the Visual Audit Sheet (VAS) or its computer generated replacement, the Basic Training Record (BTR). These documents are a compilation of various personal and administrative data.

The fourth grouping contained factors that could be extracted from the Record of Emergency Data (RED). The RED contains information about dependents and next of kin. It is carefully and regularly updated because of its importance in case of the injury or death of the Marine. The fifth grouping contained factors that could be extracted from page 9 of the SRB. Page 9 deals with awards and recognition.

The sixth grouping is a tally of the positive and negative entries on page 11 of the SRB. Page 11 (actually, a collection of several pages) contains administrative remarks of various types. Of interest are negative entries (counselling for misbehavior, poor performance, irresponsibility) and positive entries (consideration for meritorious promotion, exceptional performance, Marine-of-the-month). Neutral entries (mandatory training completed, supply items issued) were ignored.

The seventh grouping is a single value--the number of Marine Corps Institute (MCI) courses completed by the Marine. The Marine Corps Institute is a service sponsored correspondence school offering hundreds of military-related courses free of charge. As enrollment is usually voluntary, the number of MCI courses completed is sometimes used as an indication of desire to improve one's job performance or level of knowledge. Each MCI course completed is listed on page 8a of the SRB.

The last grouping contains average proficiency and conduct markings found on page 4 of the SRB. Periodic proficiency and conduct markings are the principal means of documenting the performance and behavior of enlisted Marines in the first four ranks, Private (E-1) through Corporal (E-4). A score (0 to 5 in increments of .1) is assigned to each area (proficiency and conduct) according to specific criteria established by Marine Corps Order. In general, scores of 4.0 and above are considered satisfactory.

Use of the data entry sheet speeded the data gathering by ensuring that each section of the SRB was required only once.

4. Extraction Process

Visits were made to the participating units according to a schedule arranged by appointment during the first two days. It had been determined at the outset that the scope of inquiry would be constrained by geography (only one data gathering trip would be funded), manpower (only the thesis student would be involved), and time. Another significant limitation arose from the nature of the data itself. Because the purpose of the pretrial confinement advisor is to provide a recommendation as to whether or not to confine an accused Marine to ensure his presence at trial, the ideal population from which to select samples would be the set of all Marines accused of violations of the UCMJ. Of this population, some will flee to avoid prosecution, and some will not. This property (flight) was considered to be the dependent variable against which all the independent variables (29 of the 35 data elements) were to be correlated and compared. The problem arises in that some subset of this ideal population is confined (Figure 13). These confined Marines have lost the opportunity to demonstrate their willingness to either remain or flee, thus subsets A and B in Figure 13 (Confined and would have fled, Confined but would not have fled) virtually indistinguishable. While there are statistical methods that might allow us to infer the applicability of conclusions drawn from subsets C and D (not confined) to the entire population, it was felt that attempting such an inference from such a necessarily small sample would be stretching its significance. The scope of the study was therefore narrowed to the population of all unconfined Marines accused of violations of the UCMJ. This implies that the first-cut, version 0 of the PCA prototype will be valid only for evaluating Marines who would otherwise not be confined. This was considered acceptable since the primary function of

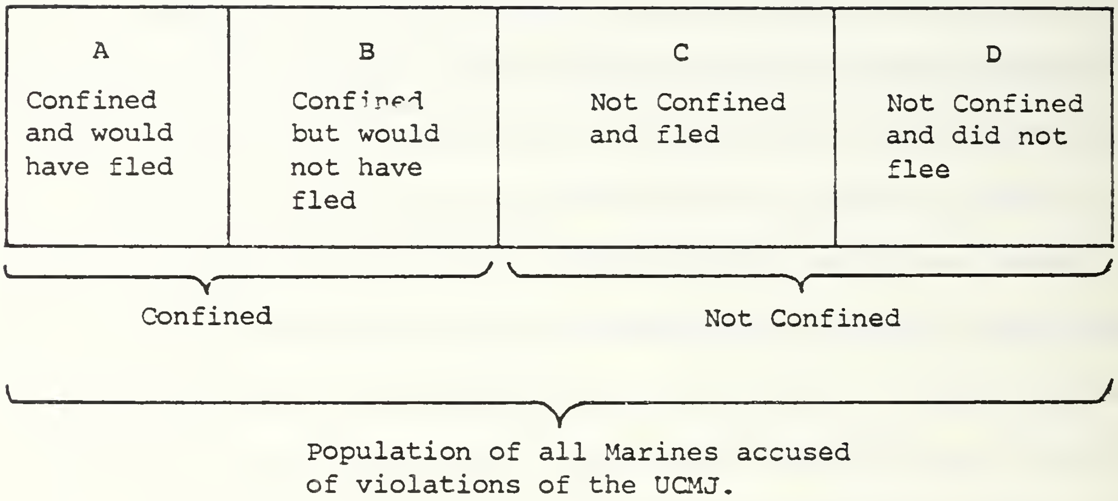

A
Confined and would have fled
B
Confined but would not have fled
C
Not Confined and fled
D
Not Confined and did not flee
Confined
Not Confined
Population of all Marines accused of violations of the UCMJ.

Figure 13. Target Population Breakdown

a version 0 prototype is to demonstrate feasibility of the approach and to provide a starting point for further refinements. Succeeding iterations in the prototyping process (versions 1, 2, etc.) can overcome these limitations as more time, manpower, and funding are made available. With this caveat, the gathering of data proceeded.

Legal Officers of the participating units were asked to provide SRB's of Marines who:

- At some time had pending charges,
- Were not confined while charges were pending,
- Either had their charges resolved through legal action or fled to avoid prosecution.

The third point was included to eliminate such aberrations as Marines who died while pending charges, those who avoided prosecution because of lack of jurisdiction due to flawed enlistment contracts, or those in other infrequently encountered situations that might tend to confuse the issue.

5. Problems Encountered

Three significant problems were encountered during the data collection phase of the project.

a. Availability of SRB's

A unit will have custody only of the SRB's for those Marines assigned to it. The types of Marines in the target population (those accused of violations of the UCMJ) transfer more frequently for the following reasons:

- Administrative discharges. Charges pending disposition by Special Court-Martial are often dropped when the Marine accepts a Good of the Service (GOS) discharge. A

GOS may be offered when it is determined that a Marine has no realistic potential for satisfactory service. The discharge is effected under "other than honorable" conditions.

- Unit Rotation. Infantry Battalions (7 of the 8 units participating) rotate as a unit to an overseas station for six months at a time. This occurs every two years; six months overseas, 18 months in the United States, and so on. Marine pending Special Courts-Martial are not allowed to deploy overseas, and are transferred to a neighboring Battalion.
- Deserters. Those who flee to avoid prosecution are carried on the rolls of their units for only 30 days. On the 31st day of absence, they are dropped from the rolls of their units and their SRB's are sent to Headquarters Marine Corps.

These factors, combined with normal transfer activity, severely limited the number of SRB's in the target population that were available for examination. While legal personnel were able to provide lists of a large number of Marines who fit the sample criteria (20-30 names per Battalion was common), only a fraction of these were still members of the units (4-8 was most common).

b. Time Limitations

Because the data gathering was extremely time-constrained, only 2 to 3 hours were allotted per Battalion. This was significant because some SRB's that would have been available a day or two hence were not available during the particular hours appointed. Reoccurring situations were:

- Marines were pending new charges and their SRB's were at the Office of the Staff Judge Advocate (OSJA) for trial preparation.

- Marines were pending administrative discharge, and their SRB's had been sent to the Administrative Separations section at higher headquarters.
- Administrative actions or non-judicial punishments were being conducted by the Companies (next lower unit) and the persons with custody of the SRB's were not available.

While some of the above SRB's could have been conveniently examined during follow-up visits, attempting to obtain them within the time allotted would have seriously disrupted important ongoing legal and administrative procedures.

c. Historical Data

It was apparent from the first interviews that many of the factors expected to be most important were elements of information not captured in historical data. Although they may have been known at the time the pretrial confinement decision was made, they were not recorded and are not accessible in retrospect. This was felt to be the most significant limitation of the study--that perhaps the most informative factors could not be examined because the data gathering necessarily depended upon historical data.

B. ANALYSIS METHODOLOGY

Once collected, the data was coded for easy manipulation and placed into a MINITAB worksheet (Appendices A and B). MINITAB is a flexible statistical analysis program resident on the IBM 3033 mainframe computer at the Naval Postgraduate School.

Selection of a procedure for the analysis of the data involved looking ahead to its eventual incorporation into the M.1 expert system development language. The types of numbers that would be ideal for such translation would be probabilities, correlation coefficients, or other metrics that can be related mathematically to M.1's certainty factors. [Ref. 9:p. 4-16] One statistical procedure that would seem to provide exactly what is wanted comes from multiple regression analysis, specifically the linear probability model, or binomial logit. [Ref. 10:p. 173] It was recognized, however, that such an approach is inappropriate in this case because of the fundamental difference between an expert system and a mathematical model. A linear probability model takes the form of an equation

$$D_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} \cdots \varepsilon_i$$

where D_i is the dependent variable of interest, the X's are the independent variables that correspond to the 35 factors observed, and the β's are the regression coefficients determined by the multiple regression analysis process. This equation forms the heart of a mathematical model that would attempt to explain statistically, at one stroke, the contribution of each of the 35 variables to the likelihood of D_i being 1. The end product is a probability; precisely what is sought, but derived in a numerical, algorithmic manner. An expert system, on the other hand, infers its end recommendation based on rules and facts built into its knowledge-base. While the regression equation will evaluate each set of independent variables in the same way, the expert system may manipulate each set differently. [Ref. 7: p. 45] Multiple regression analysis and expert system analysis are, in fact, competing strategies. They produce different results in different ways [Ref. 2:lectures 3 & 4]. The all-in-one probability D_i may be useful in its own right, but is incompatible with, and difficult to integrate into, an expert system, particularly M.1, because it was derived through an approach which a "Knowledge Engineer" would consider inappropriate to the unstructured, non-algorithmic nature of the problem at hand [Ref. 9:pp. 1-5,1-14]. There is no way to directly translate the mathematical operations of a linear probability model into the knowledge base rules of an expert system.

The approach of the "Knowledge Engineer"--a term meaning one who builds knowledge bases--should be one of looking for general relationships among the variables and incorporating the results into the rules and facts making up the M.1 knowledge base. In this regard, Simon's approach appeared both sensible and appealing:

> To begin with, saturate yourself in the raw data. Look and look some more at the original data sheets and at the computer printouts of the data. You should look for any regularities. Ask yourself what might be interesting

> about the data. Look for simple facts, because the simple facts are the most important. Your knowledge of your discipline should tell you what facts and patterns are of importance in your discipline, and it is that knowledge that will guide your search.
>
> Certainly you should be looking for big differences, especially in a comparison research problem, differences that will be apparent to simple eyeball inspection. Differences that require subtle statistical analysis are usually not so valuable.
>
> Do your looking with pencil and paper in hand. Compute simple estimates for various variables--averages, totals, first-half-versus-second-half calculations, percentages, and so forth. Look at this raw material as if someone had given it to you as pieces cut with a jigsaw and you are to find the key to the puzzle.
>
> Make crude tables and graphs. If you think you see a relationship between two variables, plot them on a graph. [Ref. 11:p. 380]

The particular knowledge representation language of M.1 lends itself easily to single-statement rules which allow each variable to contribute its part towards the sought for conclusion. Because of this, each independent variable can be examined, analyzed and incorporated into M.1 individually. This is in contrast to multiple regression analysis which would consider the contribution of all variables at once. Multiple regression analysis is still the dominant approach, having yet to be successfully challenged by expert systems. In addition to Simon's recommended use of exploratory plots, means, tallies, etc., the use of two-way frequency tables to quantify strong associations in terms of a phi coefficient (ϕ) seemed particularly useful since ϕ can be translated almost directly into M.1's confidence factor.

[Ref. 12:p. 463] These techniques are more fully explained in Chapter IV, Evaluation of Data.

The translation of data relationships into knowledge base rules, then, is not a purely mechanical procedure, but rather a judgmental, almost artistic process. The associations detected in the data were mingled with the expert opinion picked up in the interviews, and tempered by the experience of the knowledge engineer. This is the controlling concept of expert system development--the encapsulation of heuristic processes, which are refined by the iterative production and testing of successive prototypes.

C. PROTOTYPING

The concept of prototyping as a development strategy has been discussed in Chapter II. The details of the implementation of version 0 of the PCA prototype will be discussed in Chapter V.

IV. EVALUATION OF DATA

After the data was collected, it was quantified for coding into a statistical analysis worksheet. This was done so the data could be manipulated and analyzed with the aid of a computer. These steps are discussed below.

A. QUANTIFICATION OF INPUT

Quantification--or coding--of the data in this case meant the assigning of numbers to represent the values collected for each of the 35 variables of interest. For example, the 17th variable contains values to indicate whether an accused Marine is married or not. The values collected on the data entry sheet were YES (meaning the accused is married) and NO (meaning the accused is not married). Because the MINITAB statistical analysis program only works with numbers, these possible responses were coded:

1 - YES - The accused is married
0 - NO - The accused is not married

Each of the 35 variables was so quantified. The key to this coding is included as Appendix A. The entire set of data, in coded form, was then entered into a MINITAB worksheet for analysis (Appendix B).

B. ANALYSIS OF VARIABLES

Analysis was approached in the manner advocated by Simon, in that the researcher first "immersed" himself in the data, looking at it in different ways, from both macro and micro perspectives. [Ref. 11]

The first impression gained was that some of the potentially useful associations apparent in the data gained from the infantry battalions were being masked by the support battalion data. Personnel in the support battalion are recent graduates of the Marine Corps Recruit Depot. Typically they have no prior service, no prior unauthorized absences, no disciplinary history, less than a year in service, are of uniform age and rank, etc. The sample from the support battalion reflected this, producing remarkably sterile data. Based only on the support battalion cases in the data, a reasonable inference was that if the propensity to flee could be predicted for this population at all, it would have to be based on factors other than those focused on in this study. Infantry units, on the other hand, lack this uniformity of population. The new personnel have already gone through the training provided by the support battalion, and join a population rich in variety and experience. It became apparent, then, that the two populations needed to be approached differently. The variables gathered, however, appeared to be meaningful only with reference to the infantry units. Consequently, the support battalion data was removed from the worksheet, restricting the target population to infantry units and further reducing the sample size (to 44). It had been previously determined that any conclusions reached about the target population based upon the data collected would be tentative due to unavoidable sampling bias and small sample size. The further reduction of the sample by another nineteen cases made this even more true. This was considered acceptable for the initial development of the prototype, however, based on the assumption that concept demonstration and methodology are more important in a version 0 than is absolute accuracy of either the variables or the output (which can be "tuned" into the system through subsequent versions, based on larger, more unbiased, and more comprehensive studies).

Although each of the variables was looked at in a number of ways, the most informative proved to be through the use of frequency tables. Each variable for which an association was sought was arranged in a matrix with possible values for the variable represented as columns. It was then compared against variable number 9 (whether the Marine fled or not), the possible values of which are represented as rows. Figure 14 illustrates a generic example. The cells formed by the intersection of the columns and rows contain the number of cases that fit into each category.

		Possible values of the independent variable			
		0	1	2	Total
Possible values of the dependent variable	0	11	6	4	21
	1	9	9	5	23
	Total	20	15	9	44

Figure 14. Frequency Table

	0	1	2	Total
0	55%	40%	44%	48%
1	45%	60%	56%	52%
Total	100%	100%	100%	100%

Figure 15. Column Percentages

Computing column percentages facilitated comparison of the different values of an independent variable (Figure 15). If the percentages on a given row were similar across the columns, this was taken to indicate that the different values of the variable had little effect on likelihood of flight.

The end-product sought was a measure of association between each value of a variable and the likelihood of flight (a value of 1 on the y-axis). A useful computation in this regard was the phi coefficient (ϕ) which measures the change in column percentages between two adjacent columns and characterizes the association between the row variable and the column variable in terms of direction and strength. [Ref. 12:pp. 463-464] A phi coefficient of -1 indicates perfect negative correlation, while +1 indicates perfect positive correlation. A phi coefficient of 0 indicates no association whatever between the variables. The phi coefficient, however, is applicable only where the variable has two mutually exclusive possible values (such as yes and no). In other cases, the column percentages were compared against the percentages of the entire sample and probabilities were estimated based on the differences. Where appropriate, the significance of the differences between columns was measured using a two-tailed t-test based on a 95% confidence interval.

The derivation of these measures of association for each of the 29 independent variables is discussed below. (Of the 35 factors, four contained administrative data, one was the dependent variable, and the confinement variable was not considered for reasons discussed earlier. This left 29 variables with which to work.)

1. Variables 1, 2, 3, and 9

Variables 1, 2 and 3 were identification information and not intended to be independent variables for analysis purposes. Variable 9 indicated unauthorized absence, and was the dependent variable for analysis.

2. Variable 4: Rank

With respect to rank, both the frequency table (Table 1) and the frequency table by column percentages (Table 2) contain useful information. First of all, the cumulative column at far right in the percentages table indicates that the sample is divided roughly in half with respect to the dependent variable; that is, the number who

TABLE 1

RANK

		E1	E2	E3	E4	E7	All
UA	0	3	7	8	4	1	28
	1	7	6	8	0	0	21
	All	10	13	16	4	1	44

fled and the number who stayed are about equal. All of the variables examined will reflect about this same proportion between those who fled and those who stayed, although the exact numbers may vary somewhat due to missing values in the data. Comparing each value column (rank) with the cumulative column in the percentage table shows a possibly significant percentage variation with respect to E-1's, little percentage variation from the cumulative with respect to E-2's and E-3's, and significant percentage variation for E-4's (Corporals) and above. Combining like values together produces Table 3.

TABLE 2

RANK

		E1	E2	E3	E4	E7	All
UA	0	30	54	50	100	100	52
	1	70	46	50	0	0	48
	All	100	100	100	100	100	100

TABLE 3

RANK

		E1	E2-E3	E4 & Above	All
UA	0	3(30)	15(52)	5(100)	23(52)
	1	7(70)	14(48)	0(0)	21(48)
	All	10(100)	29(100)	5(100)	44(100)

We can examine the significance of the differences between the column values by comparing the differences of the means of two columns ($u_1 - u_2$) with the size of the 95% confidence interval calculated using a standard two-tailed t-test. The results of this comparison are shown in Table 4.

TABLE 4

RESULTS OF T-TEST (RANK)

Columns	($u_1 - u_2$)	95% Confidence Interval
E1 and E2-E3	.21724	.374
E2-E3 and E4 & Above	.48276	.2275
E1 and E4 & Above	.7	.47547

If the confidence interval is less than or equal to the difference in the means, we can be 95% confident that the difference is statistically significant, indicating that the sample size is adequate to establish the association. If the confidence interval is greater than the difference of the means, we can be less confident in the significance of the difference, indicating that a larger sample size is recoded to clarify the association.

The figures suggest that, out of a sample equally divided between those who fled and those who stayed, 70% of the Privates will have fled, PFC's and Lance Corporals will be divided about the same as the sample as a whole, and none of the Corporals or above will have fled. The percentages for Corporals and above, however, are based on very small numbers, as shown in Table 1, making the 100% figure suspect. Experience (personal knowledge of Non-Commissioned Officers who fled to avoid trial) will tend to moderate that figure downward. These percentages roughly corroborate the consensus expressed during the interview phase of the study that greater rank generally indicated greater dependability; Sergeants are more dependable than Corporals, Staff Sergeants more dependable than Sergeants, and so on. Only under conditions of very serious charges would a Staff Non-Commissioned Officer (E-6 or above) be considered a flight risk. A reasonable first-cut estimate of the likelihood of an unconfined Marine to flee based on rank might therefore be:

E-1 (Private)	70%
E-2 (Private First-Class	50%
E-3 (Lance Corporal)	50%
E-4 (Corporal)	30%
E-5 (Sergeant)	20%
E-6 (Staff Sergeant)	10%
E-7 (Gunnery Sergeant)	10%

3. Type of Charges Pending

The frequency table and column percentage table for this variable are combined below for convenience in Table 5.

TABLE 5

TYPE OF CHARGES

	0	1	2	3	4	5	7	All
0	0(0)	11(58)	3(50)	2(50)	6(67)	1(100)	0(0)	23(52)
1	4(100)	8(42)	3(50)	2(50)	3(33)	0(0)	1(100)	21(48)
All	4(100)	19(100)	6(100)	4(100)	9(100)	1(100)	1(100)	44(100)

During data gathering, 0 values were collected for this variable to indicate that, while charges were not actually pending, they were expected. The idea was that anticipation of charges might generate the same sort of motivation to flee as the fear of the consequences of trial itself. Overlooked was the fact that the accused Marines were anticipating particular types of charges which:

1. Would fit in one of the other categories of values,
2. Would generate different degrees of flight motivation,
3. Were not captured in the data.

It was therefore determined that 0 values for this variable did not contribute useful information. Consequently, the first column is not included in the analysis.

The next three value columns, indicating unauthorized absence (1), larceny (2) and drug abuse (3), did not vary significantly from the cumulative column percentages, indicating no strong association with the flight variable. This conclusion is based on the assumption that the proportion of those who fled to those who stayed in the sample approximates that same proportion in the population itself. The baseline against which all column percentages are measured for significance, then, is this 50%-50% split. A variable value whose column percentages vary significantly from this may indicate an association with the flight variable, either positive or negative. A potentially significant variation in the column percentages for value 4 (Bad checks) may indicate an inverse association with the flight variable, suggesting that those accused of writing bad checks are more likely to stay than another accused Marine chosen at random from the population. The 100% figures in value columns 6 (assault) and 7 (misc. offenses) are based on single case entries, and are therefore suspect.

First-cut estimates of the likelihood of flight for unconfined Marines based on the type of offenses charged might be:

Bad Checks	30%
All other offenses	50%

4. Seriousness of the Charges

The combined frequency table for this variable shows an unexpected result (Table 6). First of all, there are no extreme values in the sample; while there are six levels of seriousness, only the middle four are represented. A possible explanation for this might be that the cases involving the lowest level of seriousness (one minor charge)

TABLE 6

SERIOUSNESS OF CHARGES

		2	3	4	5	All
UA	0	0(0)	4(44)	6(60)	13(68)	23(58
	1	2(100)	5(56)	4(40)	6(32)	17(42)
	All	2(100)	9(100)	10(100)	19(100)	40(100)

were disposed of quickly through non-judicial punishment or administrative action and perhaps were thought to not rise to the level of importance required for the study. On the other end of the scale (grave charges), it is conceivable that confinement was directed in all such cases.

Secondly, the column percentages seem to suggest a definite negative association between seriousness and likelihood of flight. This conclusion runs counter to conventional wisdom, manifested through the interviews, that likelihood of flight increases with the seriousness of the charge. A possible explanation for this result might be that Commanders, acting on this commonly accepted assumption, confined most of those with serious charges and were more lenient with those pending minor charges. This would leave in the target population most of those pending minor charges while, of those pending more serious charges, only the most reliable would remain. In light of the original caveat, that the system would apply only to those who would otherwise not be confined, this unexpected negative association may be reasonable after all.

The significance of the difference among the column values is illustrated in Table 7. It is clear from Table 7 that confidence in the difference among the column values must run considerably below 95%.

TABLE 7

RESULTS OF T-TEST

Columns	$(u_1 - u_2)$	95% Confidence Interval
2 and 3	.4450	.91855
2 and 4	.6000	.84547
2 and 5	.6842	.72328
3 and 4	.1550	.50540
3 and 5	.2392	.4104
4 and 5	.0842	.3935

Acceptable first-cut estimates of likelihood of flight of those not confined, based on the seriousness of the charges might be:

Multiple minor charges	65%
One major charge	55%
Multiple major charges	40%
Serious charges........................	30%

5. Confined

This variable contained values to indicate whether the accused was confined or not. Early in the data gathering the scope of the study was restricted to non-confinees, and all cases with a positive value in this variable were removed from consideration.

6. Surrendered or Apprehended

This variable applied to those pending charges for unauthorized absence and indicated whether the absence was terminated by voluntary surrender or involuntary apprehension. Conventional belief is that those who surrender are more likely to stay than those who are captured. This belief may be manifested in the data by the fact that, of the 20 cases in which unauthorized absence was a pending charge, every one of the Marines surrendered. The assumption is that those apprehended were confined, thus removing them from the target population. Table 8 is the combined frequency table for this variable. Note the

TABLE 8

SURRENDERED OR APPREHENDED

		Surr	N/A	All
UA	0	11(55)	12(50)	23(52)
	1	9(45)	12(50)	21(48)
	All	20(100)	24(100)	44(100)

absence of an apprehended column, as there were no apprehended Marines in the sample. The N/A column contains those to whom the Surrendered/Apprehended distinction does not apply. Column percentages for those surrendering were virtually identical to the cumulative percentages, suggesting that the data tells us nothing useful in predicting likelihood of flight.

7. Previous Unauthorized Absence

As the combined frequency table (Table 9) shows the number of prior absences in the sample ranged from zero to three. Column percentages seem to show erratic behavior; a decrease, then an increase, then a decrease in likelihood of flight, moving from zero to three. Considering the small sample size, it was felt that this result might be because the granularity of distinction was too fine. A more reasonable, at least intuitively appealing, result emerges when the columns are combined, as shown in Table 10. The

TABLE 9

PREVIOUS UNAUTHORIZED ABSENCE (INSTANCES)

		0	1	2	3	All
UA	0	12(57)	5(71)	3(30)	3(50)	23(52)
	1	9(43)	2(29)	7(70)	3(50)	21(48)
	All	21(100)	7(100)	10(100)	6(100)	44(100)

TABLE 10

PREVIOUS UNAUTHORIZED ABSENCE (INSTANCES)

		<2	≥2	All
UA	0	17(61)	6(38)	23(52)
	1	11(39)	10(62)	21(48)
	All	28(100)	16(100)	44(100)

significance of the differences between the column values is illustrated in Table 11.

TABLE 11

RESULTS OF T-TEST (PREVIOUS UA)

Column	$(u_1 - u_2)$	95% Confidence Interval
<2 and ≥2	.23214	.31558

First-cut estimates of likelihood of flight for unconfined Marines based on previous unauthorized absence might therefore be:

Less than two prior UA	40%
Two or more prior UA	62%

8. Previous Non-Judicial Punishments

This variable, thought originally to hold much predictive promise, exhibited erratic behavior across five values in the sample, ranging from zero to four. Granularity was again suspected, so the columns were combined in different ways to try and bring into focus any informative patterns. Column percentages for every combination of columns tested varied insignificantly from the cumulative column, indicating that the data has no predictive value. This disappointing result was attributed to the small sample size. The combined frequency table for this variable is show as Table 12.

TABLE 12

PREVIOUS NJP (INSTANCES)

		0	1	2	3	4	All
UA	0	7(50)	6(75)	4(40)	3(38)	3(75)	23(52)
	1	7(50)	2(25)	6(60)	5(62)	1(25)	21(48)
	All	14(100)	8(100)	10(100)	8(100)	4(100)	44(100)

9. Court-Martial Convictions

Although not designed as a bivariate variable (one with only two possible values, indicating either the presence or absence of a condition), this variable manifested values in the sample ranging from zero (no court-martial convictions) to one (one court-martial conviction). This allowed the researcher to use phi coefficient calculation to measure the strength of association between the variables. Examination of the frequency table (Table 13) suggests that some positive association exists.

TABLE 13

COURT-MARTIAL CONVICTIONS

		0	1	All
UA	0	20(56)	3(38)	23(52)
	1	16(44)	5(62)	21(48)
	All	36(100)	8(100)	44(100)

Entering the tally values from the matrix quadrants into the phi equation:

$$\frac{ad - bc}{\sqrt{(a+b)(c+d)(a+c)(b+d)}}$$

produces a phi coefficient of:

$$\phi = +.14$$

Although manifesting a definite positive association, the small magnitude of the coefficient requires that the association be characterized as weak. [Ref. 12:p. 464]

10. Reductions

This variable showed no significant variation from the cumulative across the values in the sample, suggesting little predictive value in the data (Table 14). The

TABLE 13

COURT-MARTIAL CONVICTIONS

		0	1	All
UA	0	20(56)	3(38)	23(52)
	1	16(44)	5(62)	21(48)
	All	36(100)	8(100)	44(100)

the tally values from the matrix quadrants into t
tion:

$$\frac{ad - bc}{\sqrt{(a+b)(c+d)(a+c)(b+d)}}$$

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Although manifesting a definite positive
tion, the small magnitude of the coefficient requ
e association be characterized as weak. [Ref. 12:

Reductions

This variable showed no significant variation f
mulative across the values in the sample, suggest
e predictive value in the data (Table 14). The

11. Years of Active Duty

This variable had seven values in the sample, six of which ranged uniformly from zero to five, with one outlying value of 13. It initially exhibited the same sort of erratic behavior found in other variables with more than two values, and over-fine granularity became suspect. A significant association came into focus when the values were grouped to reflect enlistment periods; that is, years in service from zero to three (first enlistment) were combined into one group, and year in service greater than three (second enlistment or beyond) were combined into another. The results are shown in Table 16.

TABLE 16

ENLISTMENT

		1ST	2D OR >	All
UA	0	13(41)	6(86)	19(49)
	1	19(59)	1(14)	20(51)
	All	32(100)	7(100)	39(100)

Variation of the column percentages from the cumulative for the first enlistment was not considered significant. Variation for the second grouping, however, was pronounced. The significance of the difference between the two columns is illustrated in Table 17.

TABLE 17

RESULTS OF T-TEST (ENLISTMENTS)

Columns	$(u_1 - u_2)$	95% Confidence Interval
1st and 2nd or greater	.451	.4057

Table 17 clearly shows that the difference between the first enlistment and other enlistments is significant to at least the 95% confidence level.

First-cut estimates of the likelihood of flight for unconfined Marines based on years of active duty might therefore justifiably be:

First enlistment	50%
Second or greater enlistment	15%

12. Population Group

As shown in Table 18, none of the column percentages for any of the racial groups varied significantly from the

TABLE 18

POPULATION GROUPS

		Cau	Blk	Hisp	All
UA	0	10(45)	5(62)	2(40)	17(49)
	1	12(55)	3(38)	3(60)	18(51)
	All	22(100)	8(100)	5(100)	35(100)

cumulative percentages, suggesting that the data has no predictive value. Combining like columns produced a comparison between Black and Non-black as shown in Table 19.

TABLE 19

POPULATION GROUP SUMMARY

		Black	Non-black
UA	0	5(62)	12(44)
	1	3(38)	15(56)
	All	8(100)	27(100)

The significance of the difference between the two columns is shown in Table 20.

TABLE 20

RESULTS OF T-TEST (POPULATION GROUPS)

Columns	$(u_1 - u_2)$	95% Confidence Interval
Black & Non-black	.18	.4182

This parallels conventional wisdom manifested in the interviews. None of the legal officers or Commanders interviewed was willing to say that race was a significant factor in predicting unauthorized absence.

13. Age

This variable had nine values in the sample and manifested the same sort of turbulent behavior indicative of over-fine granularity in previous variables. The data suggested natural "break points" which resulted in the groupings shown in Table 21.

TABLE 21

AGE

		19-20	21-23	24-32	All
UA	0	1(20)	13(54)	5(83)	20(50)
	1	8(80)	11(46)	1(17)	20(50)
	All	10(100)	24(100)	6(100)	40(100)

The significance of the differences among the columns is illustrated in Table 22.

TABLE 22

RESULTS OF T-TEST (AGE)

Columns	$(u_1 - u_2)$	95% Confidence Interval
19-20 and 21-33	.4306	.3751
21-23 and 24-32	.2917	.4601
19-20 and 24-32	.7223	.4143

These column percentage variations were the most significant observed to this point and resulted in the following estimates of likelihood of flight for unconfined Marines based on age:

Under 21	80%
21 - 23	50%
Over 23	17%

14. Marital Status

Column percentages showed no significant variation from the cumulative, suggesting no predictive value (Table 23). This was confirmed by computation of a phi coefficient of .05. Since phi coefficients up to .3 are considered evidence of "weak" association, the magnitude of the coefficient was considered insignificant.

TABLE 23

MARRIED

		0	1	All
UA	0	13(52)	7(47)	20(50)
	1	12(48)	8(53)	20(50)
	All	25(100)	15(100)	40(100)

15. Children

In less than one quarter of the cases studied did the Marine have children. Although the column percentage variations seemed significant (Table 24), they were based on very small numbers and thus suspect. Combining the numbers of children to form two groups, those with children and those without, diluted the differences to the point where no significant percentage variation remained. (See Table 25.)

TABLE 24

NUMBER OF CHILDREN

		0	1	3	All
UA	0	16(52)	2(33)	2(67)	20(50)
	1	15(48)	4(67)	1(33)	20(50)
	All	31(100)	6(100)	3(100)	40(100)

TABLE 25

NUMBER OF CHILDREN (SUMMARY)

		None	One or More	All
UA	0	16(52)	4(44)	20(50)
	1	15(48)	5(56)	20(50)
	All	31(100)	9(100)	40(100)

The significance of the difference between the two columns is shown in Table 26.

TABLE 26

RESULTS OF T-TEST (CHILDREN)

Columns	$(u_1 - u_2)$	95% Confidence Interval
None and One or More	.071	.3916

It was concluded that the data had no predictive value. Conventional wisdom holds that a Marine with children is more responsible than one without. This remains to be demonstrated statistically.

16. GCT

This variable had 19 values in the sample, making interpretation of the column percentages difficult. A useful grouping of values proved to be:

Below average (95 and below)

Average (95 - 105)

Above average (105 and above)

as shown in Table 27 below.

TABLE 27

GCT (INTELLIGENCE)

		<95	95-105	>105	All
UA	0	3(43)	10(63)	5(45)	18(53)
	1	4(57)	6(37)	6(55)	16(47)
	All	7(100)	16(100)	11(100)	34(100)

Column percentages seem to contradict the generally accepted feeling that more intelligent Marines are less likely to flee than less intelligent Marines. Rather it suggests that Marines of average intelligence are less likely to flee than those with below average or above average intelligence.

Combining like columns produces the comparison shown in Table 28.

TABLE 28

GCT-INTELLIGENCE (SUMMARY)

		Average	Non-average	All
UA	0	10(63)	8(44)	18(53)
	1	6(37)	10(56)	16(47)
	All	16(100)	18(100)	34(100)

The significance of the difference between the two columns is shown in Table 29.

TABLE 29

RESULTS OF T-TEST (GCT)

Columns	$(u_1 - u_2)$	95% Confidence Interval
Ave and Non-ave	.18	.3545

First-cut estimates of likelihood of flight for unconfined Marines based on intelligence as measured by the GCT might therefore be:

GCT of 95 and below	50%
GCT of 95 to 105	38%
GCT of 105 or above	50%

17. Education Level

Data as to education level showed no reliable significant percentage variation from the cumulative, suggesting that the data has no predictive value (Table 30).

TABLE 30

LAST GRADE COMPLETED

		10	11	12	13	All
UA	0	0(0)	1(50)	19(54)	0(0)	20(50)
	1	2(100)	1(50)	16(46)	1(100)	20(50)
	All	2(100)	2(100)	35(100)	1(100)	40(100)

The conventional wisdom that better educated Marines are less likely to flee than less educated ones remains to be demonstrated statistically.

18. Immediate Family in the Area

Data as to whether the Marine has immediate family living in the local area showed no reliable, significant percentage variation from the cumulative, suggesting that the data has no predictive value (Table 31). The significance of the difference between the two relevant columns is illustrated in Table 32. The conventional wisdom that having family in the local area affects the likelihood of flight (some thought positively, some thought negatively) remains to be demonstrated.

TABLE 31

IMMEDIATE FAMILY IN LOCAL AREA

		No	Yes	N/A	All
UA	0	2(33)	5(56)	16(55)	23(52)
	1	4(67)	4(44)	13(45)	21(48)
	All	6(100)	9(100)	29(100)	44(100)

TABLE 32

RESULTS OF T-TEST (LOCAL FAMILY)

Columns	$(u_1 - u_2)$	95% Confidence Interval
No and Yes	.2223	.5953

19. Children in School

As shown in Table 33, data as to whether the Marine had children in school showed no reliable, significant percentage variation from the cumulative, suggesting that the data had no predictive value.

TABLE 33

CHILDREN IN LOCAL SCHOOLS

		No	Yes	N/A	All
UA	0	4(40)	1(50)	18(56)	23(52)
	1	6(60)	1(50)	14(44)	21(48)
	All	10(100)	2(100)	32(100)	44(100)

20. Family in Quarters

Only one Marine in the sample had a family living in government quarters. Obviously, no conclusions can be reached based on such a small representation.

21. Parents with Separate Addresses

This variable was included as a surrogate to capture the influence of "troubled" homes, as indicated by parents who separated either before or after the time the Marine enlisted (Table 34). Column percentage variation seemed to

TABLE 34

PARENTS WITH SEPARATE ADDRESSES

		No	Yes	All
UA	0	17(57)	6(43)	23(52)
	1	13(43)	8(57)	21(48)
	All	30(100)	14(100)	44(100)

suggest very weak association with likelihood of flight, as confirmed by a phi coefficient computation of +.13.

22. Home of Record Near Place of Duty

This variable was selected to capture the influence of having a Marine's home within three hours drive of his place of duty upon his likelihood of flight. Only three Marines in the sample fell into that category, rendering any potentially promising column percentage variations suspect. It was concluded that the data had no predictive value.

23. Unit Awards

Unit awards are ribbons awarded to a unit as a whole. It is generally felt that they are indicative of high morale and competency within the unit, although individuals may be exceptions. This variable had five values in the sample, ranging from zero to four. Most of the Marines in the sample had zero or one unit award, while only five had two or more. This situation seemed well suited for conversion of the variable to bivariate form by combining all the values of one or above into one group, as shown in Table 35.

TABLE 35

UNIT AWARDS

		0	1 or more	All
UA	0	5(26)	18(72)	23(52)
	1	14(74)	7(28)	21(48)
	All	19(100)	25(100)	44(100)

The column percentage variations seem to indicate a significant negative association between possession of a unit award and likelihood of flight. This is confirmed by computation of a phi coefficient of +.45, which Anderson and Sclove characterize as a "medium" association. [Ref. 12:p. 464] Although mentioned in the interviews, this variable appears to have a stronger negative association with likelihood of flight than the experts seemed to indicate they might expect.

24. Personal Awards

This variable captured data indicating whether the individual Marine had received a personal award, an honor bestowed in recognition of individual superior performance, as differentiated from superior unit performance. Only one Marine in the sample had received an individual award, too small a representation for evaluation.

25. Good Conduct Medals

Good conduct medals are awarded to enlisted Marines for good behavior over an extended period (four years). Only four Marines in the sample had received good conduct medals, too small a representation for evaluation despite the very promising column percentage variations, as shown in Table 36 below.

TABLE 36

NUMBER OF GOOD CONDUCT MEDALS

		0	1	4	All
UA	0	20(50)	2(67)	1(100)	23(52)
	1	20(50)	1(33)	0(0)	21(48)
	All	40(100)	3(100)	1(100)	44(100)

This would seem to be a promising area of investigation during some future, more comprehensive study.

26. Meritorious Masts

Meritorious Masts are a lower level of recognition than medals, consisting of commendations awarded by a Commander to Marines in his unit recognizing superior achievement or effort. The data showed no reliable, significant column percentage variations from the cumulative, suggesting that the data has no predictive value (Table 37).

TABLE 37

NUMBER OF MERITORIOUS MASTS

		0	1	2	All
UA	0	19(53)	3(43)	1(100)	23(52)
	1	17(47)	4(57)	0(0)	21(48)
	All	36(100)	7(100)	1(100)	44(100)

27. Letters of Appreciation

Similar to a meritorious mast, a letter of appreciation may come from outside the unit as well. Like meritorious masts, the data for letters of appreciation manifested no predictive value (Table 38).

TABLE 38

LETTERS OF APPRECIATION

		0	1	3	All
UA	0	18(51)	4(57)	1(50)	23(52)
	1	17(49)	3(43)	1(50)	21(48)
	All	35(100)	7(100)	2(100)	44(100)

28. Positive Page 11 Entries

Page 11 of the Service Record Book is a section where the Commander records administrative comments, positive, negative and neutral. As most of the Marines in the sample had zero or one positive comment on page 11, with four Marines having two or more, the variable was converted to bivariate form, as shown in Table 39 below.

TABLE 39

POSITIVE PAGE 11 ENTRIES

		0	1 or more	All
UA	0	10(40)	13(68)	23(52)
	1	15(60)	6(32)	21(48)
	All	25(100)	19(100)	44(100)

Column percentage variations from the cumulative seem to indicate a negative association; that is, unconfined Marines with at least one positive page 11 entry are less likely to flee to avoid trial. This is confirmed by computation of a phi coefficient of -.28, on the borderline between a weak and a medium-strength association in terms of magnitude.

29. Negative Page 11 Entries

This variable was exhaustively searched for patterns or relationships as it is so heavily relied upon by commanders and legal officers in making pretrial confinement decisions. Despite its promise, no reliable, significant indications were found that the data contained predictive value (Table 40).

TABLE 40

NEGATIVE PAGE 11 ENTRIES

		0	1 or more	All
UA	0	3(50)	20(53)	23(52)
	1	3(50)	18(47)	21(48)
	All	6(100)	38(100)	44(100)

30. Marine Corps Institute Courses Completed

The data for this variable also lacked predictive value, as shown in Table 41 below.

TABLE 41

NUMBER OF MCI COURSES COMPLETED

		0	1 or more	All
UA	0	10(53)	12(55)	22(54)
	1	9(47)	10(45)	19(46)
	All	19(100)	22(100)	41(100)

Even when placed in bivariate form, distinguishing between those who had completed at least one MCI course and those who had not, the calculated phi coefficient was near zero.

31. Average Proficiency Mark and Average Conduct Mark

The experience of the researcher and information gained through the interviews at the beginning of the study confirm that average proficiency and conduct marks are relied on heavily in making the pretrial confinement decision. The consensus is that Marines with records of poor performance or conduct are less dependable. While this may be the case, based on the small sample used in this study, average proficiency and conduct marks for those Marines who fled were virtually indistinguishable from those who stayed, both as to mean and mix. The calculated means are shown in Table 42 below.

TABLE 42

AVERAGE PROFICIENCY AND CONDUCT MARKS

	Fled	Stayed
Ave PRO Mark	4.2	4.1
Ave CON Mark	3.9	3.9

The data with respect to this variable therefore appeared to have no predictive value.

C. SUMMARY OF ANALYSIS

Recognizing the limitations of the study, principally the unavoidable selection bias and small sample size, analysis proceeded in an attempt to isolate tentative associations between the factors considered and the likelihood of flight. Implementation of these conclusions will constitute a first version prototype of a pretrial confinement expert system. The usefulness of this first effort lies in exploring methodologies, uncovering promising directions for development, and demonstrating feasibility of the concept. Any serious effort to complete the development of a functional pretrial confinement expert system will require a study of much greater scope and intensity so as to overcome the limitations mentioned previously.

Of the 29 independent variables in the 35 data elements collected, eight seemed to manifest promising predictive value. These were:

- Rank
- Seriousness of the Charges
- Prior Unauthorized Absence
- Years of Service
- Age
- GCT (intelligence)
- Unit Awards
- Positive Page 11 Entries

Seven of these factors exhibited associations with likelihood of flight that were intuitive and tended to support commonly held assumptions. Seriousness of Charges, however, showed an association inverse to that conventionally supposed; that is, the data seemed to indicate that likelihood of flight decreased as the seriousness of the Charges increased.

Twenty-one of the factors manifested no ability to predict the likelihood of flight, either because of the limitations of the study or because no association exists. In most of these cases, only a better study will be able to determine which of these two reasons apply.

Other surprising results were:

- Lack of evidence of association with regard to previous non-judicial punishment, court-martial convictions, and negative page 11 entries, all of which are used heavily to predict likelihood of flight.
- Indistinguishability of proficiency and conduct marks between those who fled and those who stayed.

V. DEVELOPMENT OF THE PROTOTYPE

A. IMPLEMENTATION OF EXPERT KNOWLEDGE INTO M1

1. PCA Overview

As mentioned in Chapter II, the Pretrial Confinement Advisor (PCA), version 0, was built using the M1 knowledge system software tool by Tecknowledge, Inc. M1 is a flexible expert system framework that operates primarily using a backward-chaining inference process. [Ref. 9:p. 4-11] Backward chaining is driven by the search for a value for an expression, which is designated as the "goal." In the case of PCA, the goal is an expression called "recommendation" which may be instantiated with one of several values recommending confinement or non-confinement with varying degrees of urgency. The value given to "recommendation" will depend on the degree of certainty associated with a second expression called "ua," representing the likelihood of unauthorized absence.

Also explained in Chapter II was the fact that the backward-chaining inference process operates through the interaction of rules and facts in the knowledge base. The implementation of expert knowledge about pretrial confinement into PCA, then, consists of the translation of each notion into rules that produce the expression "ua" with a given certainty.

2. Notions to be Implemented

The study isolated eight factors which seemed to manifest an association with the likelihood of flight, and gave an idea as to the strength of that association. These factors were:

- Rank
- Seriousness of the Charges
- Prior Unauthorized Absence
- Years of Service
- Age
- GCT (intelligence)
- Unit Awards
- Positive Page 11 Entries

Much of the data collected and analyzed during the course of the study proved inconclusive, due in great degree to the flaws and limitations of the study itself. Many potentially significant factors were not investigated because their values could not be determined on the basis of historical data. Finally, it is probable that some significant factors were simply overlooked by the researcher. Despite these obstacles, an expert system allows consideration of non-demonstrable notions and relationships based on experience, common sense, and rules-of-thumb. The following additional factors were added to PCA based on their importance to the "experts" interviewed, and on the experience of the researcher:

- Whether Pending Charges include Unauthorized Absence
- Surrendered or Apprehended
- Reputation for Personal Integrity
- Potential for Harassment
- History of Alcohol or Drug Abuse
- Civilian Charges Pending
- Significant Family Problems
- Marital or Romantic Conflicts
- Subjective Evaluation of Level of Maturity
- Subjective Evaluation of Level of Self-Esteem
- Recently Reduced by Legal Action

3. Conversion of Probabilities to Certainty Factors

Analysis of the data collected during the study isolated eight significant factors. In each case, the strength of the factor's association with the likelihood of flight was estimated either in terms of a probability or a phi coefficient. Translation of either of these measures into the M1 knowledge system language requires conversion into "certainty factor" form. As explained in Chapter II, certainty factors are somewhat analogous to probabilities, but span a scale from -100 (definitely not or 0 probability) to +100 (Definitely or 1.0 probability). A certainty factor of 0 indicates there is no evidence either way (Analogous to .5 probability). As the end points on both scales mean essentially the same thing, the relationship is linear and a conversion equation cf = (200 * Pr) - 100

where Pr represents probability and cf represents certainty factor, can be used to convert one to the other.

The obvious similarity of scale between the phi coefficient and the certainty factor makes its conversion a matter of moving the decimal point two places to the right.

A graphic comparison of these three scales is provided in Figure 16.

4. Implementation of Factors

Capturing the results of the study and the experience of the experts involved translating the predictive value of each of the factors listed above into M1 rules.

a. Rank

Conversion of the estimates of likelihood of flight, derived during analysis, into certainty factors allowed the development of the following six rules with respect to rank:

- If rank = Private
  then ua = yes cf 40

- If rank = PFC
  then ua = yes cf 0

- If rank = Lance Corporal
  then ua = yes cf 0

- If rank = Corporal
  then ua = yes cf -40

- If rank = Sergeant
  then ua = yes cf -60

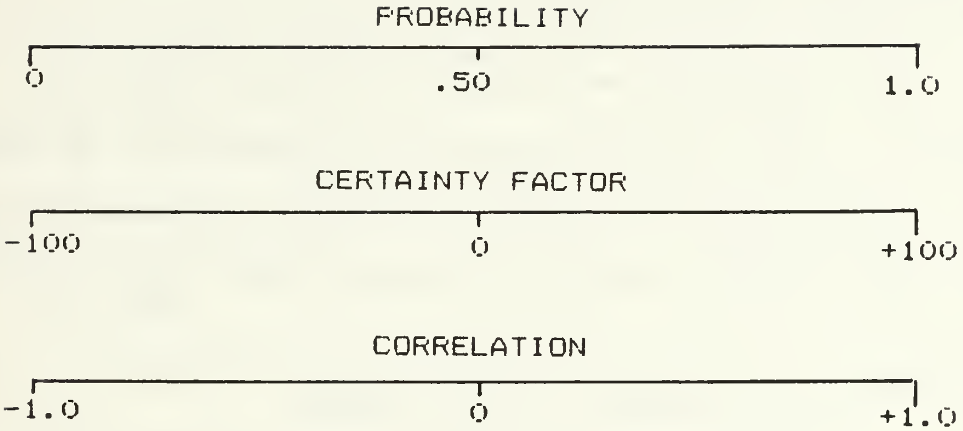

Figure 16. Comparison of Scales

- If rank = Staff Sergeant or above
  then ua = yes cf -80

A rule which results in a conclusion with a certainty factor of 0 has no effect on the inference process. The primary rules in this knowledge base have conclusions which either add certainty to, or subtract certainty from, the likelihood of flight, as represented by the variable "ua." Rules which leave the certainty of the variable "ua" unchanged, that is, have a certainty factor of 0, have the same effect as no rule at all. It is for this reason that during implementation the rules concerning PFC's and Lance Corporals were omitted from the actual PCA. The possible values for the proposition expression (in this case, rank) were also coded numerically for ease of entry. The actual words, instead of numbers, are used here for clarity.

b. Seriousness of the Charges

Results of the analysis with regard to seriousness of the charges were translated into four rules:

- If seriousness = multiple minor charges
  then ua = yes cf 30
- If seriousness = one major charge
  then ua = yes cf 10
- If seriousness = multiple major charges
  then ua = yes cf -20
- If seriousness = serious charges
  then ua = yes cf -40

c. Prior Unauthorized Absence

Analysis of the data concerning prior unauthorized absence allowed the development of two rules:

- If Prior-ua = less than two
  then ua = yes cf -20

- If prior-ua = two or more
  then ua = yes cf 24

d. Years of Service

Analysis of the data involving years of service allowed the development of two rules. As before, only rules resulting in conclusion with certainty factors different than 0 were actually implemented.

- If enlistment = first
  then ua = yes cf 0

- If enlistment = second or greater
  then ua = yes cf -70

e. Age

Analysis of the age data allowed development of three rules:

- If age = under 21
  then ua = yes cf 60

- If age = 21 to 23
  then ua = yes cf 0

- If age = over 23
  then ua = yes cf -66

f. GCT (intelligence)

Analysis of the data related to GCT scores allowed development of one significant rule:

- If GCT = average
  then ua = yes cf -24

g. Unit Awards

Analysis of the data related to the possession of unit awards allowed the development of one significant rule:

```
- If unit-award = yes
  then ua = yes cf -45
```

h. Positive Page 11 Entries

Analysis of the positive page 11 entry data allowed the development of one significant rule:

```
- If pos-entry = yes
  then ua = yes cf -28
```

i. Unauthorized Absence in the Charges

The generally accepted consensus manifested in the interviews was that Marines pending charges for unauthorized absence were greater flight risks because they had already demonstrated their tendency to solve their problems by running away. This was considered especially true for those who are apprehended, the idea being that because they did not make a deliberate decision to surrender they still may think that running away is the solution. Quantification of these ideas is a subjective process, especially the first estimates. The resulting certainty factors should be the subject of "tuning" as the prototyping process proceeds from version to version. Reasonable first-cut estimates might justifiably lead to the development of the following rules:

```
- If pending-ua = yes
  then ua = yes cf 50
```

- If pending-ua = yes
  and apprehended = yes
  then ua = yes cf 80

j. Reputation for Personal Integrity

Such a factor is doubly subjective; it requires a subjective evaluation of integrity, then a subjective quantification of that evaluation. Fine distinctions in this area are clearly inappropriate. Nevertheless, great stock is placed in this factor by those who make pretrial confinement decisions regularly. Based on the interviews, the following rules seem reasonable:

- If reputation = excellent
  then ua = yes cf -40
- If reputation = good
  then ua = yes cf -20
- if reputation = mixed
  then ua = yes cf 0
- If reputation = poor
  then ua = yes cf 50

k. Potential for Harassment

Marines pending charges sometimes become a target for low-level harassment, especially in units with poor leadership or unit discipline. This was a frequently mentioned reason for flight from such units. This notion can be captured in the following rules:

- If harassment-potential = high
  then ua = yes cf 60
- If harassment-potential = moderate
  then ua = yes cf 30
- If harassment-potential = low
  then ua = yes cf 0

l. History of Alcohol or Drug Abuse

The consensus in this area was that substance abusers were less reliable because they had developed "escapist" ways of dealing with problems. This idea may appropriately be captured by the following rules:

- If hist-abuse = serious
  then ua = yes cf 50

- If hist-abuse = moderate
  then ua = yes cf 30

m. Civilian Charges Pending

This frequently mentioned factor was believed by the researcher to be a surrogate to indicate the depth of an accused Marine's legal problems. An accused who is pending both military and civil charges may perceive himself to be in serious trouble, increasing the motivation to flee. The following rule may properly capture this idea:

- If civ-charges = yes
  then ua = yes cf 40

n. Significant Family Problems

A common motivation to leave the unit has proven to be the presence of serious problems at home. This might be the sickness of a loved one (which does not rise to the level of severity required for emergency leave), the floundering of a family business, or an emotional crisis where the Marine sees his moral support as critical. Such unauthorized absence may occur without other charges pending. The following rule attempts to capture this factor:

- If fam-problems = yes
  then ua = yes cf 30

o. Marital or Romantic Conflicts

Highly emotional romantic conflicts were universally cited as a common motivation for unauthorized absence. The following rule attempts to capture this idea:

- If rom-prob = yes
  then ua = yes cf 30

p. Level of Maturity

This requires a subjective evaluation, but can be based upon objective criteria, such as job performance, timely payment of debts, volunteer work in the community, demeanor, etc. The following rule attempts to capture this idea:

- If maturity = high
  then ua = yes cf -40
- If maturity = moderate
  then ua = yes cf 0
- If maturity = low
  then ua = yes cf 50

q. Level of Self-Esteem

This factor is related to maturity, but is difficult to determine from objective criteria. It must rather be established subjectively based on the accused's demeanor during the pretrial confinement interview. The following rules apply:

- If esteem = high
  then ua = yes cf -40
- If esteem = moderate
  then ua = yes cf 0

```
- If esteem = low
  then ua = yes cf 40
```

r. Recent Reduction in Grade

Reduction in grade is a serious punishment in the Marine Corps. In addition to the penalty in reduced pay, the Marine suffers a loss of authority and esteem in the eyes of his peers. He is now on an equal footing with those who previously were subordinates. The humiliation of such a punishment is often credited as the cause of unauthorized absence. The following rule captures this idea:

```
- If recent-reduction = yes
  then ua = yes cf 40
```

B. IMPLICATIONS OF VERSION 0

Throughout this chapter the tentativeness of the ideas incorporated in the rules has been stressed. The concept of prototyping allows some flexibility in the initial development of a project in order to establish a starting place for further refinements. A common danger in prototyping, however, is that version 0 is accepted by the users for testing, and is used indefinitely without undergoing further development. [Ref. 2:Ref. 7] While regrettable in any prototyping project, this practice would be especially inappropriate with regard to PCA. The study upon which it is based was extremely limited and freighted with caveats; the interviews from which expert opinion was solicited were short and limited to a small population of experts, and allowed no opportunity for follow-up. The rules proposed in this chapter cannot confidently be considered more than a foundation upon which to build with further study and with field testing. The implication of a version 0 is that there will be a version 1, version 2, and so on until satisfactory performance is demonstrated.

VI. CONCLUSIONS AND RECOMMENDATIONS

A functional version 0 of the Pretrial Confinement Advisor prototype was developed based on the rules outlined in Chapter V. The program listing of this expert system is included as Appendix D.

A. CONCLUSIONS

Several useful conclusions become apparent when the results of the project are measured against the original research questions.

1. Question #1

From the information normally available to a Marine Corps Commanding Officer, can factors be identified that will enable him to predict whether or not an accused Marine will attempt to escape to avoid trial by court-martial?

Despite significant limitations, several such factors were identified. More importantly, promising areas and lucrative directions were pointed out that seem ripe for further study. It is reasonable to infer that with more time, effort and funding, much more can be learned about predicting unauthorized absence. This chapter contains recommendations for proceeding in this effort. The answer to the first research question is unquestionably "yes."

2. Question #2

Can such factors be incorporated into a rule-based expert system to advise commanders on the pretrial confinement decision?

The factors identified in the study were analyzed for predictive value, combined with the expert opinion of experienced practitioners, and implemented into a functional prototype of the Pretrial Confinement Advisor, built upon the M.1 knowledge system software tool. While the recommendations of the system lack refinement, the concept has been demonstrated to be feasible. The answer to research question #2 is "yes."

3. Question #3

Can a method be devised to determine if the use of this expert system results in a net benefit to the units that employ it?

The answer to research question #3 is also "yes." The recommended field testing procedures are discussed below.

B. RECOMMENDATIONS

As mentioned previously, production of a version 0 prototype is only the first step in the prototyping development process. Version 0 is tested by the intended user, who provides evaluation input leading to the development of an improved version 1. Version 1 is then evaluated, producing input leading to the development of version 2, and so on. Beyond this, however, two specific recommendations are offered.

1. A Better Study

The limitations of the study were stressed previously. As the project progressed they became more and more apparent. Version 1 should not proceed without overcoming the handicaps of the original study, namely:

- Reliance upon historical data. Because many potentially useful factors known to a commander at the time of the decision are not recorded, reliance upon historical data severely restricts the scope of the study. Also, as most of data used was contained in the Service Record Books (SRB), and as SRB's were not randomly available, selection bias was introduced into the sample, the strength and direction of which was impossible to determine.

- Time and Funding Limitations. Because of these limits, the interviews were rushed and shallow, with no opportunity for follow-up. Data gathering was also rushed, resulting in a very small sample.

It is recommended that future studies overcome these by:

- Focusing on a larger number of units over a longer period of time (six months or more).

- Using a more comprehensive data entry sheet addressing all potentially relevant factors.

- Capturing data from all cases referred to trial in the units studied, thus eliminating one source of selection bias.

- Capturing data at the time the pretrial decision is made, thus assuring availability of relevant factors.

This procedure will ensure a large enough sample to allow confirmation or negation of the conclusions reached in the original study.

2. Field Testing

Addressing the third research question, determining the usefulness of the Pretrial Confinement Advisor, will require field testing over an extended period (six months or more). The procedure should involve a concept known as "parallel operation," which generically means running new system at the same time as the old and comparing the results. Data for each Marine referred to trial (not confined) would be entered into PCA and a recommendation recorded. The Commander, on the other hand, would make his pretrial decision in the normal way, uninfluenced and unaware of the PCA recommendation. At this stage, the Commander could not be aware of the PCA recommendation because his uninfluenced decisions form the "control" against which the PCA output will be compared. Notation would be made in the records to indicate those who fled and those who did not. At the end of the field test, the results would be compared to determine if the use of PCA would have manifested an improvement over reliance on the commander's judgement alone.

More extensive field testing might involve full use of the system by comparing error rates of PCA-assisted Commanders with error rates of unassisted Commanders. Care should be taken throughout to emphasize that PCA is an aid to--not a replacement for--the Commander's judgment.

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APPENDIX A

DATA CODING KEY

Column No.	Description and Legal Values
1	Data Entry Sheet Number (1-64)
2	Type of Unit 1 - Infantry Battalion 2 - Support Battalion
3	Unit Designation 1 - 2/1 2 - 1/5 3 - 3/5 4 - 2/9 5 - 1/7 6 - 3/7 7 - 3/9 8 - Spt Bn, ITS
4	Rank 1 - Private 2 - Private First Class 3 - Lance Corporal 4 - Corporal 5 - Sergeant 6 - Staff Sergeant 7 - Gunnery Sergeant
5	Type of Charges Pending 0 - No Charges 1 - Unauthorized Absence 2 - Larceny 3 - Drug Abuse 4 - Bad Checks 5 - Disrespect 6 - Assault 7 - Miscellaneous Charges
6	Seriousness of the Charges 1 - One Minor Charge 2 - Multiple Minor Charges 3 - One Major Charge 4 - Multiple Major Charges

5 - Serious Charges
6 - Grave Charges

7 Confinement
0 - Not Confined
1 - Confined

8 Surrendered or Apprehended
0 - Surrendered
1 - Apprehended
2 - N/A (Charges do not include UA)

9 Fled to Avoid Trial
0 - Did Not Flee
1 - Fled
2 - N/A (Was Confined)

10 Previous Instances of unauthorized Absence
(0-N)

11 Previous Non-Judicial Punishments
(0-N)

12 Court-Martial Convictions
0 - None
1 - One Summary Court-Martial
2 - One Special Court-Martial
3 - Multiple Courts-Martial

13 Reductions Resulting from Legal Action
(0-N)

14 Years of Active Duty
(0-N)

15 Population Group
1 - Caucasian
2 - Black
3 - Hispanic
4 - Asian

16 Age
(0-N)

17 Marital Status
0 - Not Married
1 - Married

18 Children
(0-N)

19 GCT (Intelligence)
(N)

20 Last Grade Completed (Education)
(0-16)

21 Immediate Family in Local Area
0 - No
1 - Yes
2 - N/A (Unmarried)

22 Children in Local Schools
0 - No
1 - Yes
2 - N/A (No Children)

23 Family Living in Government Quarters
0 - No
1 - Yes
2 - N/A (Unmarried)

24 Parents with Separate Addresses
0 - No
1 - Yes

25 Home of Record within Three Hours Drive of Place of Duty
0 - No
1 - Yes

26 Number of Unit Awards
(0-N)

27 Number of Personal Awards
(0-N)

28 Number of Good Conduct Medals
(0-N)

29 Number of Meritorious Masts
(0-N)

30 Number of Letters of Appreciation
(0-N)

31 Number of Positive Page 11 Entries
(0-N)

32 Number of Negative Page 11 Entries
(0-N)

33	MCI Courses Completed (0-N)
34	Average Proficiency Mark (0.0-5.0)
35	Average Conduct Mark (0.0-5.0)

APPENDIX B

DATA IN MINITAB WORKSHEET FORMAT

```
MTB > retrieve 'aptc'
MTB > print cl-c35
 ROW      C1     C2     C3     C4     C5     C6     C7     C8     C9    C10    C11    C12    C13

   1       1      1      1      3      2      3      0      2      1      0      0      0      0
   2       2      1      1      4      3      5      0      2      0      0      0      0      0
   3       3      1      1      3      1      5      0      0      1      0      0      0      0
   4       4      1      1      2      1      5      0      0      1      0      1      0      1
   5       5      1      1      3      4      4      0      2      1      2      2      0      0
   6       6      1      1      3      1      3      0      0      1      1      2      0      0
   7       7      1      1      2      1      5      0      0      1      2      3      0      2
   8       8      1      1      3      1      5      0      0      1      0      0      0      0
   9       9      1      2      2      1      5      0      0      1      0      0      0      0
  10      10      1      2      2      4      5      0      2      0      0      1      0      0
  11      11      1      2      2      4      5      0      2      0      1      1      0      0
  12      12      1      2      2      4      5      0      2      0      0      0      0      0
  13      13      1      3      2      1      5      1      1      2      1      1      0      1
  14      14      1      3      2      1      4      0      0      0      3      2      0      1
  15      15      1      3      1      1      2      0      0      1      3      3      1      1
  16      16      1      3      4      1      4      0      0      0      1      1      0      0
  17      17      1      3      1      0      *      0      2      1      2      3      0      1
  18      18      1      3      3      2      4      0      2      0      0      1      0      0
  19      19      1      4      2      6      5      0      2      0      1      4      0      1
  20      20      1      4      2      4      4      0      2      1      3      4      0      1
  21      21      1      4      1      3      5      0      2      1      2      2      1      1
  22      22      1      4      3      1      5      0      0      0      2      3      0      0
  23      23      1      4      1      1      5      0      0      0      2      4      1      2
  24      24      1      4      4      1      5      0      0      0      0      0      0      0
  25      25      1      4      3      4      5      0      2      0      1      2      0      0
  26      26      1      4      1      7      2      0      2      1      2      2      1      2
  27      27      1      5      3      2      3      0      2      0      0      0      1      1
  28      28      1      5      3      1      5      0      0      0      0      0      0      0
  29      29      1      5      1      4      4      0      2      0      2      4      0      1
  30      30      1      5      2      1      3      0      0      0      0      3      0      1
  31      31      1      5      3      4      4      0      2      1      0      0      0      0
  32      32      1      5      1      0      *      0      2      1      1      3      0      2
  33      33      1      5      2      0      *      0      2      1      0      0      0      0
  34      34      1      6      7      1      3      0      0      0      0      0      0      0
  35      35      1      6      1      2      4      0      0      1      3      2      1      2
  36      36      1      6      3      3      3      0      2      1      0      0      0      0
  37      37      1      6      3      1      5      0      0      0      1      2      0      0
  38      38      1      7      1      1      3      0      0      1      2      1      1      0
  39      39      1      7      1      1      3      0      0      0      3      1      1      1
  40      40      1      7      2      2      3      0      2      1      2      3      0      1
  41      41      1      7      3      1      5      0      0      0      0      2      0      0
  42      42      1      7      4      2      5      0      2      0      0      0      0      0
  43      43      1      7      3      0      *      0      2      1      0      2      0      0
  44      44      1      7      3      4      4      0      2      0      0      1      0      0
  45      45      1      7      2      3      4      0      2      0      3      3      0      2
  46      46      2      8      1      0      *      0      2      1      2      2      0      0
  47      47      2      8      1      0      *      0      2      1      0      0      0      0
  48      48      2      8      2      0      *      0      2      1      0      0      0      0
  49      49      2      8      1      0      *      0      2      1      0      0      0      0
  50      50      2      8      1      0      *      0      2      1      0      0      0      0
  51      51      2      8      1      0      *      0      2      1      0      0      0      0
  52      52      2      8      2      0      *      0      2      1      0      0      0      0
  53      53      2      8      2      0      *      0      2      1      0      0      0      0
  54      54      2      8      2      0      *      0      2      1      0      0      0      0
  55      55      2      8      1      0      *      0      2      1      0      0      0      0
  56      56      2      8      2      0      *      0      2      1      0      0      0      0
  57      57      2      8      1      0      *      0      2      1      0      1      0      0
```

```
       58    58    2    8    2    1    1    0    0    0     0     0     0     0
       59    59    2    8    1    1    4    0    0    0     0     0     0     0
       60    60    2    8    2    0    *    0    2    1     0     0     0     0
       61    61    2    8    1    1    3    0    1    1     0     1     0     0
       62    62    2    8    2    6    5    0    2    1     0     0     0     0
       63    63    2    8    1    6    5    0    2    1     0     0     0     0
       64    64    2    8    2    0    *    0    2    1     0     0     0     0

      ROW   C14   C15   C16   C17   C18    C19   C20   C21   C22   C23   C24   C25

        1     1     1    20     0     0     96    12     2     2     2     0     0
        2     5     *    25     1     1      *     *     1     0     0     0     0
        3     2     1    20     0     0     87    12     2     2     2     1     0
        4     2     2    23     0     0      *    12     2     2     2     1     0
        5     3     1    21     0     1      *    12     0     2     0     0     0
        6     4     3    23     1     0     93    12     0     0     0     1     0
        7     3     1    22     0     0     96    11     2     2     2     1     1
        8     2     1    20     1     0    102    12     1     0     0     0     0
        9     *     *     *     *     *      *     *     2     2     2     1     0
       10     2     1    22     0     0     95    12     2     2     2     0     0
       11     *     *     *     *     *      *     *     2     2     2     0     0
       12     *     *     *     *     *      *     *     2     2     2     0     0
       13     2     3    22     0     0      *     *     2     2     2     1     1
       14     1     3    23     1     1     96    12     0     0     0     1     0
       15     2     1    20     0     0    117    10     2     2     2     0     0
       16     3     *    30     1     3     99    12     0     0     0     0     0
       17     1     *    19     1     0    107    12     1     0     0     0     0
       18     *     *    21     *     *      *    12     2     2     2     0     0
       19     3     1    21     0     0    108    12     2     2     2     1     0
       20     2     2    21     0     0     94    12     2     2     2     0     0
       21     1     1    19     0     0    116    12     2     2     2     1     1
       22     4     1    22     0     0    102    12     2     2     2     0     *
       23     4     1    24     0     0    109    12     2     2     2     0     0
       24     4     1    22     1     0     99    12     1     0     1     1     0
       25     4     2    24     0     0     89    12     2     2     2     0     0
       26     2     1    23     0     0      *    12     2     2     2     0     0
       27     1     2    23     0     0    102    12     2     2     2     1     0
       28     2     3    21     1     0     97    12     1     2     0     0     0
       29     1     1    21     0     0    113    12     2     2     2     0     0
       30     1     1    20     0     0     96    12     2     2     2     1     0
```

```
 31     2     1    21     0     0   102    12     2     2     2     0     0
 32     1     1    21     1     0    80    12     2     2     2     0     0
 33     0     *    22     0     0     *    12     2     2     2     0     0
 34    13    12    32     1     3   108    12     1     1     0     0     0
 35     2     3    21     0     0   124    12     2     2     2     0     0
 36     2     1    20     1     1   107    10     1     1     0     1     0
 37     2     1    20     1     0   116    12     1     2     0     0     0
 38     1     1    20     1     1    95    12     1     0     0     0     0
 39     1     2    21     0     0    99    12     2     2     2     0     0
 40     3     2    22     1     1    97    12     0     0     0     1     0
 41     *     *     *     0     0     *    11     2     2     2     1     1
 42     3     2    21     0     0    92    12     2     2     2     0     0
 43     3     3    25     1     3   111    13     0     0     0     0     0
 44     3     1    22     0     0    95    12     2     2     2     0     0
 45     2     1    21     0     0    80    12     2     2     2     0     0
 46     0     1    18     0     0    92    12     2     2     2     0     0
 47     0     1    18     0     0   126    12     2     2     2     1     0
 48     0     1    18     0     0   109    11     2     2     2     0     0
 49     0     1    19     0     0   115    12     2     2     2     1     0
 50     0     1    19     0     0   108    12     2     2     2     1     0
 51     0     1    18     0     0   107    12     2     2     2     0     0
 52     0     1    18     0     0    97    12     2     2     2     0     0
 53     0     1    18     0     0   117    12     2     2     2     0     0
 54     0     2    22     0     0   117    14     2     2     2     0     0
 55     0     1    19     0     0    99    12     2     2     2     1     0
 56     0     1    19     0     0   100    12     2     2     2     1     0
 57     0     1    19     0     0   113    11     2     2     2     1     0
 58     0     1    19     0     0   111    12     2     2     2     1     0
 59     0     1    19     0     0    82    12     2     2     2     1     0
 60     0     1    18     0     0   127    12     2     2     2     1     0
 61     0     1    19     0     0   120    12     2     2     2     1     0
 62     0     1    18     0     0   102    12     2     2     2     0     0
 63     0     1    19     0     0   111    12     2     2     2     0     0
 64     0     3    18     0     0   118    11     2     2     2     1     0

ROW   C26   C27   C28   C29   C30   C31   C32   C33    C34    C35

  1     0     0     0     0     0     0     0     0    4.2    4.4
  2     0     0     0     0     0     0     1     0    4.1    4.1
  3     0     0     0     1     0     1     1     0    4.5    4.5
```

4	0	0	0	0	1	0	2	0	3.8	3.8
5	3	0	0	0	1	3	4	1	4.3	4.1
6	1	0	1	1	3	1	3	7	4.4	4.3
7	0	0	0	0	0	0	3	2	4.1	3.8
8	0	0	0	0	0	0	0	0	4.0	3.9
9	0	0	0	0	0	0	2	*	*	*
10	0	0	0	0	0	1	0	*	*	*
11	1	0	0	0	0	1	2	3	4.0	3.8
12	1	0	0	0	0	0	5	0	4.3	3.7
13	0	0	0	0	0	0	5	4	3.7	3.1
14	0	0	0	0	0	0	1	0	2.5	2.0
15	0	0	0	0	0	0	4	1	3.7	3.4
16	1	0	0	0	0	1	0	1	4.5	4.4
17	0	0	0	0	1	0	3	0	4.3	4.0
18	1	0	0	0	0	1	4	0	3.6	3.6
19	1	0	0	0	0	1	4	2	4.1	3.8
20	0	0	0	1	0	0	2	1	4.4	3.8
21	0	0	0	0	0	0	2	0	4.4	4.1
22	2	0	0	0	0	1	5	5	4.1	3.8
23	2	0	0	2	0	1	3	2	3.9	4.4
24	2	0	1	0	3	4	1	8	4.6	4.6
25	1	0	1	1	1	0	2	5	4.3	4.3
26	0	0	0	0	0	0	2	3	3.8	3.6
27	1	0	0	0	0	2	0	0	3.9	3.9
28	1	0	0	0	0	1	2	1	4.4	3.5
29	1	0	0	0	0	0	3	0	4.0	3.6
30	1	0	0	0	0	0	3	0	3.9	3.5
31	1	0	0	0	0	1	6	2	4.3	4.3
32	1	0	0	0	0	0	3	*	3.7	3.4
33	0	0	0	0	0	0	1	0	4.3	4.1
34	1	1	4	0	0	1	5	20	*	*
35	0	0	0	0	0	0	1	0	4.2	3.3
36	1	0	0	0	0	0	0	4	4.4	4.2
37	1	0	0	1	1	0	5	0	4.1	3.5
38	0	0	0	0	0	1	2	0	3.9	3.2
39	0	0	0	0	0	0	2	0	3.9	3.7
40	1	0	0	1	0	0	2	2	4.3	3.9
41	0	0	0	0	0	0	4	1	3.7	3.5
42	4	0	0	1	1	1	1	4	4.5	4.2
43	1	0	0	0	0	2	2	4	4.0	3.4

```
  44       1       0       0       0       1       1       4       2     4.3      4.2
  45       1       0       0       0       0       0       2       0     3.5      2.7
  46       0       0       0       0       0       0       1       0     3.9      4.0
  47       0       0       0       0       0       0       0       0     4.4      4.3
  48       0       0       0       0       0       0       0       0     4.2      4.2
  49       0       0       0       0       0       0       0       0     4.1      4.1
  50       0       0       0       0       0       0       0       0     4.5      4.6
  51       0       0       0       0       0       0       0       0     4.1      4.1
  52       0       0       0       0       0       0       0       0     4.4      4.4
  53       0       0       0       0       0       0       0       0     4.1      4.1
  54       0       0       0       0       0       0       0       0     4.5      4.5
  55       0       0       0       0       0       0       0       0     4.4      4.4
  56       0       0       0       0       0       0       0       0     4.2      4.3
  57       0       0       0       0       0       0       1       0     4.1      4.1
  58       0       0       0       0       0       0       0       0     4.3      4.3
  59       0       0       0       0       0       0       0       0     4.2      4.1
  60       0       0       0       0       0       0       0       0     4.1      4.1
  61       0       0       0       0       0       0       1       0     4.3      4.3
  62       0       0       0       0       0       0       0       0     4.3      4.2
  63       0       0       0       0       0       0       0       0     4.2      4.2
  64       0       0       0       0       0       0       0       0     4.2      4.3

MTB > stop
*** Minitab Release 5.1 *** Minitab, Inc. ***
IBM VM/CMS, Storage available 167334
```

APPENDIX C

MINITAB OUTPUT

```
MTB > table c9 c4


 ROWS: C9    COLUMNS: C4

           1        2        3        4        7      ALL

  0        3        7        8        4        1       23
  1        7        6        8        0        0       21
 ALL      10       13       16        4        1       44

  CELL CONTENTS --
                  COUNT

MTB > table c9 c4;
SUBC> colpercent.


 ROWS: C9    COLUMNS: C4

           1        2        3        4        7      ALL

  0      30.00    53.85    50.00   100.00   100.00    52.27
  1      70.00    46.15    50.00       --       --    47.73
 ALL    100.00   100.00   100.00   100.00   100.00   100.00

  CELL CONTENTS --
                  % OF COL

MTB > table c9 c5


 ROWS: C9    COLUMNS: C5

           0        1        2        3        4        6        7      AL

  0        0       11        3        2        6        1        0       2
  1        4        8        3        2        3        0        1       2
 ALL       4       19        6        4        9        1        1       4

  CELL CONTENTS --
                  COUNT
```

```
MTB > table c9 c5;
SUBC> colpercent.


 ROWS: C9      COLUMNS: C5

           0        1        2        3        4        6        7      ALL

  0       --    57.89    50.00    50.00    66.67   100.00       --    52.27
  1   100.00    42.11    50.00    50.00    33.33       --   100.00    47.73
 ALL  100.00   100.00   100.00   100.00   100.00   100.00   100.00   100.00

  CELL CONTENTS --
                  % OF COL

MTB > table c9 c6


 ROWS: C9      COLUMNS: C6

           2        3        4        5      ALL

  0        0        4        6       13       23
  1        2        5        4        6       17
 ALL       2        9       10       19       40

  CELL CONTENTS --
                  COUNT

MTB > table c9 c6;
SUBC> colpercent.


 ROWS: C9      COLUMNS: C6

           2        3        4        5      ALL

  0       --    44.44    60.00    68.42    57.50
  1   100.00    55.56    40.00    31.58    42.50
 ALL  100.00   100.00   100.00   100.00   100.00

  CELL CONTENTS --
                  % OF COL
```

```
MTB > table c9 c7


 ROWS: C9     COLUMNS: C7

           0      ALL

  0       23       23
  1       21       21
 ALL      44       44

  CELL CONTENTS --
                 COUNT

MTB > table c9 c7;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C7

           0      ALL

  0     52.27    52.27
  1     47.73    47.73
 ALL   100.00   100.00

  CELL CONTENTS --
                 % OF COL

MTB > table c9 c8


 ROWS: C9     COLUMNS: C8

           0        2      ALL

  0       11       12       23
  1        9       12       21
 ALL      20       24       44

  CELL CONTENTS --
                 COUNT
```

```
MTB > table c9 c8;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C8

           0        2      ALL

  0    55.00    50.00    52.27
  1    45.00    50.00    47.73
 ALL  100.00   100.00   100.00

  CELL CONTENTS --
                  % OF COL

MTB > table c9 c10


 ROWS: C9     COLUMNS: C10

           0        1        2        3      ALL

  0       12        5        3        3       23
  1        9        2        7        3       21
 ALL      21        7       10        6       44

  CELL CONTENTS --
                  COUNT

MTB > table c9 c10;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C10

           0        1        2        3      ALL

  0    57.14    71.43    30.00    50.00    52.27
  1    42.86    28.57    70.00    50.00    47.73
 ALL  100.00   100.00   100.00   100.00   100.00

  CELL CONTENTS --
                  % OF COL
```

```
MTB > table c9 c11


 ROWS: C9     COLUMNS: C11

           0        1        2        3        4      ALL

  0        7        6        4        3        3       23
  1        7        2        6        5        1       21
 ALL      14        8       10        8        4       44

  CELL CONTENTS --
                COUNT

MTB > table c9 c11;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C11

           0        1        2        3        4      ALL

  0    50.00    75.00    40.00    37.50    75.00    52.27
  1    50.00    25.00    60.00    62.50    25.00    47.73
 ALL  100.00   100.00   100.00   100.00   100.00   100.00

  CELL CONTENTS --
                % OF COL

MTB > table c9 c12


 ROWS: C9     COLUMNS: C12

           0        1      ALL

  0       20        3       23
  1       16        5       21
 ALL      36        8       44

  CELL CONTENTS --
                COUNT
```

```
MTB > table c9 c12;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C12

            0        1       ALL

  0     55.56    37.50    52.27
  1     44.44    62.50    47.73
 ALL   100.00   100.00   100.00

  CELL CONTENTS --
                  % OF COL

MTB > table c9 c13


 ROWS: C9     COLUMNS: C13

            0        1        2      ALL

  0        15        6        2       23
  1        11        6        4       21
 ALL       26       12        6       44

  CELL CONTENTS --
                  COUNT

MTB > table c9 c13;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C13

            0        1        2      ALL

  0     57.69    50.00    33.33    52.27
  1     42.31    50.00    66.67    47.73
 ALL   100.00   100.00   100.00   100.00

  CELL CONTENTS --
                  % OF COL
```

```
MTB > table c9 c14


 ROWS: C9     COLUMNS: C14

           0        1        2        3        4        5       13      ALL

 0         0        5        4        4        4        1        1       19
 1         1        5        9        4        1        0        0       20
 ALL       1       10       13        8        5        1        1       39

  CELL CONTENTS --
                  COUNT

MTB > table c9 c14;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C14

           0        1        2        3        4        5       13      ALL

 0       --     50.00    30.77    50.00    80.00   100.00   100.00    48.72
 1   100.00     50.00    69.23    50.00    20.00       --       --    51.28
 ALL 100.00    100.00   100.00   100.00   100.00   100.00   100.00   100.00

  CELL CONTENTS --
                  % OF COL

MTB > table c9 c15


 ROWS: C9     COLUMNS: C15

           1        2        3      ALL

 0        10        5        2       17
 1        12        3        3       18
 ALL      22        8        5       35

  CELL CONTENTS --
                  COUNT
```

```
MTB > table c9 c15;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C15

           1        2        3      ALL

  0    45.45    62.50    40.00    48.57
  1    54.55    37.50    60.00    51.43
 ALL  100.00   100.00   100.00   100.00

  CELL CONTENTS --
                  % OF COL

MTB > table c9 c16


 ROWS: C9     COLUMNS: C16

          19       20       21       22       23       24       25       30

  0        0        2        7        4        2        2        1        1
  1        2        6        5        3        3        0        1        0
 ALL       2        8       12        7        5        2        2        1

          32      ALL

  0        1       20
  1        0       20
 ALL       1       40
  CELL CONTENTS --
                  COUNT

MTB > table c9 c16;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C16

          19       20       21       22       23       24       25       30

  0       --    25.00    58.33    57.14    40.00   100.00    50.00   100.00
  1   100.00    75.00    41.67    42.86    60.00       --    50.00       --
 ALL  100.00   100.00   100.00   100.00   100.00   100.00   100.00   100.00

          32      ALL

  0   100.00    50.00
  1       --    50.00
 ALL  100.00   100.00
```

```
  CELL CONTENTS --
                  % OF COL

MTB > table c9 c17


 ROWS: C9     COLUMNS: C17

            0         1      ALL

  0        13         7       20
  1        12         8       20
 ALL       25        15       40

  CELL CONTENTS --
                  COUNT

MTB > table c9 c17;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C17

            0         1      ALL

  0     52.00     46.67    50.00
  1     48.00     53.33    50.00
 ALL   100.00    100.00   100.00

  CELL CONTENTS --
                  % OF COL

MTB > table c9 c18


 ROWS: C9     COLUMNS: C18

            0         1         3      ALL

  0        16         2         2       20
  1        15         4         1       20
 ALL       31         6         3       40

  CELL CONTENTS --
                  COUNT
```

```
MTB > table c9 c18;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C18

            0         1         3       ALL

  0     51.61     33.33     66.67     50.00
  1     48.39     66.67     33.33     50.00
 ALL   100.00    100.00    100.00    100.00

  CELL CONTENTS --
                  % OF COL

MTB > table c9 c19


 ROWS: C9     COLUMNS: C19

           80        87        89        92        93        94        95        96

  0         1         0         1         1         0         0         2         2
  1         1         1         0         0         1         1         1         2
 ALL        2         1         1         1         1         1         3         4

           97        99       102       107       108       109       111       113

  0         1         3         2         0         2         1         0         1
  1         1         0         2         2         0         0         1         0
 ALL        2         3         4         2         2         1         1         1

          116       117       124       ALL

  0         1         0         0        18
  1         1         1         1        16
 ALL        2         1         1        34

  CELL CONTENTS --
                  COUNT
```

```
MTB > table c9 c19;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C19

           80       87       89       92       93       94       95       96

 0      50.00      --    100.00   100.00      --       --     66.67    50.00
 1      50.00   100.00      --       --    100.00   100.00    33.33    50.00
 ALL   100.00   100.00   100.00   100.00   100.00   100.00   100.00   100.00

           97       99      102      107      108      109      111      113

 0      50.00   100.00    50.00      --    100.00   100.00      --    100.00
 1      50.00      --     50.00   100.00      --       --    100.00      --
 ALL   100.00   100.00   100.00   100.00   100.00   100.00   100.00   100.00

          116      117      124      ALL

 0      50.00      --       --     52.94
 1      50.00   100.00   100.00    47.06
 ALL   100.00   100.00   100.00   100.00

  CELL CONTENTS --
                  % OF COL

MTB > table c9 c20


 ROWS: C9     COLUMNS: C20

           10       11       12       13      ALL

 0          0        1       19        0       20
 1          2        1       16        1       20
 ALL        2        2       35        1       40

  CELL CONTENTS --
                  COUNT
```

```
MTB > table c9 c20;
SUBC> colpercent.



 ROWS: C9     COLUMNS: C20

            10        11        12        13       ALL

  0         --     50.00     54.29        --     50.00
  1     100.00     50.00     45.71    100.00     50.00
 ALL    100.00    100.00    100.00    100.00    100.00

  CELL CONTENTS --
                 % OF COL

MTB > table c9 c21



 ROWS: C9     COLUMNS: C21

             0         1         2       ALL

  0          2         5        16        23
  1          4         4        13        21
 ALL         6         9        29        44

  CELL CONTENTS --
                 COUNT

MTB > table c9 c21;
SUBC> colpercent.



 ROWS: C9     COLUMNS: C21

             0         1         2       ALL

  0      33.33     55.56     55.17     52.27
  1      66.67     44.44     44.83     47.73
 ALL    100.00    100.00    100.00    100.00

  CELL CONTENTS --
                 % OF COL
```

```
MTB > table c9 c22


 ROWS: C9     COLUMNS: C22

              0         1         2       ALL

 0            4         1        18        23
 1            6         1        14        21
 ALL         10         2        32        44

  CELL CONTENTS --
                  COUNT

MTB > table c9 c22;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C22

              0         1         2       ALL

 0        40.00     50.00     56.25     52.27
 1        60.00     50.00     43.75     47.73
 ALL     100.00    100.00    100.00    100.00

  CELL CONTENTS --
                  % OF COL

MTB > table c9 c23


 ROWS: C9     COLUMNS: C23

              0         1         2       ALL

 0            6         1        16        23
 1            8         0        13        21
 ALL         14         1        29        44

  CELL CONTENTS --
                  COUNT
```

```
MTB > table c9 c23;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C23

           0        1        2      ALL

 0     42.86   100.00    55.17    52.27
 1     57.14       --    44.83    47.73
 ALL  100.00   100.00   100.00   100.00

  CELL CONTENTS --
                  % OF COL

MTB > table c9 c24


 ROWS: C9     COLUMNS: C24

           0        1      ALL

 0        17        6       23
 1        13        8       21
 ALL      30       14       44

  CELL CONTENTS --
                  COUNT

MTB > table c9 c24;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C24

           0        1      ALL

 0     56.67    42.86    52.27
 1     43.33    57.14    47.73
 ALL  100.00   100.00   100.00

  CELL CONTENTS --
                  % OF COL
```

```
MTB > table c9 c25


 ROWS: C9     COLUMNS: C25

           0        1      ALL

  0       21        1       22
  1       19        2       21
 ALL      40        3       43

  CELL CONTENTS --
                  COUNT

MTB > table c9 c25;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C25

           0        1      ALL

  0    52.50    33.33    51.16
  1    47.50    66.67    48.84
 ALL  100.00   100.00   100.00

  CELL CONTENTS --
                  % OF COL

MTB > table c9 c26


 ROWS: C9     COLUMNS: C26

           0        1        2        3        4      ALL

  0        5       14        3        0        1       23
  1       14        6        0        1        0       21
 ALL      19       20        3        1        1       44

  CELL CONTENTS --
                  COUNT
```

```
MTB > table c9 c26;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C26

           0        1        2        3        4      ALL

  0    26.32    70.00   100.00       --   100.00    52.27
  1    73.68    30.00       --   100.00       --    47.73
 ALL  100.00   100.00   100.00   100.00   100.00   100.00

  CELL CONTENTS --
                 % OF COL

MTB > table c9 c27


 ROWS: C9     COLUMNS: C27

           0        1      ALL

  0       22        1       23
  1       21        0       21
 ALL      43        1       44

  CELL CONTENTS --
                 COUNT

MTB > table c9 c27;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C27

           0        1      ALL

  0    51.16   100.00    52.27
  1    48.84       --    47.73
 ALL  100.00   100.00   100.00

  CELL CONTENTS --
                 % OF COL
```

```
MTB > table c9 c28


 ROWS: C9     COLUMNS: C28

           0        1        4      ALL

  0       20        2        1       23
  1       20        1        0       21
 ALL      40        3        1       44

  CELL CONTENTS --
                  COUNT

MTB > table c9 c28;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C28

           0        1        4      ALL

  0    50.00    66.67   100.00    52.27
  1    50.00    33.33       --    47.73
 ALL  100.00   100.00   100.00   100.00

  CELL CONTENTS --
                  % OF COL

MTB > table c9 c29


 ROWS: C9     COLUMNS: C29

           0        1        2      ALL

  0       19        3        1       23
  1       17        4        0       21
 ALL      36        7        1       44

  CELL CONTENTS --
                  COUNT
```

```
MTB > table c9 c29;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C29

           0        1        2      ALL

  0    52.78    42.86   100.00    52.27
  1    47.22    57.14      --     47.73
 ALL  100.00   100.00   100.00   100.00

  CELL CONTENTS --
                  % OF COL

MTB > table c9 c30


 ROWS: C9     COLUMNS: C30

           0        1        3      ALL

  0       18        4        1       23
  1       17        3        1       21
 ALL      35        7        2       44

  CELL CONTENTS --
                  COUNT

MTB > table c9 c30;
SUBC> colpercent
 * Subcommand does not end in . or ;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C30

           0        1        3      ALL

  0    51.43    57.14    50.00    52.27
       51.43    57.14    50.00    52.27

  1    48.57    42.86    50.00    47.73
       48.57    42.86    50.00    47.73

 ALL  100.00   100.00   100.00   100.00
      100.00   100.00   100.00   100.00
  CELL CONTENTS --
                    % OF COL
                    % OF COL

MTB > table c9 c31


 ROWS: C9      COLUMNS: C31

            0         1         2         3         4       ALL

 0         10        11         1         0         1        23
 1         15         4         1         1         0        21
 ALL       25        15         2         1         1        44

  CELL CONTENTS --
                    COUNT

MTB > table c9 c31;
SUBC> colpercent.


 ROWS: C9      COLUMNS: C31

            0         1         2         3         4       ALL

 0      40.00     73.33     50.00        --    100.00     52.27
 1      60.00     26.67     50.00    100.00        --     47.73
 ALL   100.00    100.00    100.00    100.00    100.00    100.00

  CELL CONTENTS --
                    % OF COL

MTB > table c9 c32


 ROWS: C9      COLUMNS: C32

            0         1         2         3         4         5         6       ALL

 0          3         4         5         3         4         4         0        23
 1          3         3         8         4         2         0         1        21
 ALL        6         7        13         7         6         4         1        44

  CELL CONTENTS --
                    COUNT
```

```
MTB > table c9 c32;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C32

          0        1        2        3        4        5        6      ALL

  0   50.00    57.14    38.46    42.86    66.67   100.00       --    52.27
  1   50.00    42.86    61.54    57.14    33.33       --   100.00    47.73
 ALL 100.00   100.00   100.00   100.00   100.00   100.00   100.00   100.00

  CELL CONTENTS --
                 % OF COL

MTB > table c9 c33


 ROWS: C9     COLUMNS: C33

          0        1        2        3        4        5        7        8

  0      10        3        3        1        1        2        0        1
  1       9        3        3        1        2        0        1        0
 ALL     19        6        6        2        3        2        1        1

         20      ALL

  0       1       22
  1       0       19
 ALL      1       41
  CELL CONTENTS --
                 COUNT

MTB > table c9 c33;
SUBC> colpercent.


 ROWS: C9     COLUMNS: C33

          0        1        2        3        4        5        7        8

  0   52.63    50.00    50.00    50.00    33.33   100.00       --   100.00
  1   47.37    50.00    50.00    50.00    66.67       --   100.00       --
 ALL 100.00   100.00   100.00   100.00   100.00   100.00   100.00   100.00

         20      ALL

  0  100.00    53.66
  1      --    46.34
 ALL 100.00   100.00
```

APPENDIX D

PCA PROGRAM LISTING

```
 /*    Title: Pretrial Confinement Advisor
       Author: Major C. W. Campbell USMC
       Date: 15 March 1988 */


 if display([nl,nl,nl,tab(20),'   PRETRIAL CONFINEMENT ADVISOR',nl,
 tab(13),'The Pretrial Confinement Advisor (PCA) is designed',nl,
 tab(13),'to assist the Commander in making decisions',nl,
 tab(13),'concerning the confinement of accused Marines. This',nl,
 tab(13),'This prototype is version 0, containing the results',nl,
 tab(13),'of one preliminary study and limited interviews.',nl,
 tab(13),'It is intended for testing only, and should not',nl,
 tab(13),'be the basis for actual pretrial confinement',nl,
 tab(13),'decisions.  Interested parties may contact the',nl,
 tab(13),'author, Major C. W. Campbell, at CMC (Code MPP-20)',nl,
 tab(13),'Headquarters, U.S. Marine Corps, Washington D.C.',nl,
 tab(13),'20380-0001.',nl,nl]) and
 block is sought
 then origin.

block = origin.

initialdata = [block, origin].

goal = recommendation.

/* ***************************************************************
                            RULES
   *************************************************************** */

rule-1: if ua = yes cf N
           and N >=80
        then recommendation = 'There is a high probability
        that the accused will flee to avoid trial. PCA
        strongly recommends confinement.' cf N.

rule-2: if ua = yes cf M
           and M <80
           and M >20
        then recommendation = 'There is a moderate
        likelihood that the accused will flee to avoid trial.
        PCA recommends confinement.' cf M.
```

```
rule-3: if ua = yes cf P
           and P <= 20
           and P >= -20
        then recommendation = 'The accused falls into a category
        where the likelihood of unauthorized absence cannot be
        determined with any degree of certainty. PCA has no
        recommendation.' cf P.

rule-4: if ua = yes cf Q
           and Q < -20
        then recommendation = 'It is unlikely that the accused
        will flee to avoid trial. PCA recommends that the
        accused not be confined.' cf Q.

rule-5: if rank = N
           and N = 1
        then ua = yes cf 40.

rule-6: if rank = N
           and N = 4
        then ua = yes cf -40.

rule-7: if rank = N
           and N = 5
        then ua = yes cf -60.

rule-8: if rank = N
           and N = 6
        then ua = yes cf -80.

rule-9: if seriousness = N
           and N = 1
        then ua = yes cf 30.

rule-10: if seriousness = N
            and N = 2
         then ua = yes cf 10.

rule-11: if seriousness = N
            and N = 3
         then ua = yes cf -20.

rule-12: if seriousness = N
            and N = 4
         then ua = yes cf -40.

rule-13: if prior_ua = N
            and N = 1
         then ua = yes cf -20.
```

```
rule-14: if prior_ua = N
            and N = 2
         then ua = yes cf 24.

rule-15: if enlistment = N
            and N = 2
         then ua = yes cf -70.

rule-16: if age = N
            and N = 1
         then ua = yes cf 60.

rule-17: if age = N
            and N = 3
         then ua = yes cf -66.

rule-18: if gct = N
            and N = 2
         then ua = yes cf -24.

rule-19: if unit_award = N
            and N = 1
         then ua = yes cf -45.

rule-20: if pos_entry = N
            and N = 1
         then ua = yes cf -28.

rule-21: if pending_ua = N
            and N = 1
         then ua = yes cf 50.

rule-22: if pending_ua = N
            and N = 1
            and apprehended = M
            and M = 1
         then ua = yes cf 80.

rule-23: if reputation = N
            and N = 1
         then ua = yes cf -40.

rule-24: if reputation = N
            and N = 2
         then ua = yes cf -20.

rule-25: if reputation = N
            and N = 4
         then ua = yes cf 50.
```

```
rule-26: if harass_pot = N
            and N = 1
         then ua = yes cf 60.

rule-27: if harass_pot = N
            and N = 2
         then ua = yes cf 30.

rule-28: if hist_abuse = N
            and N = 1
         then ua = yes cf 50.

rule-29: if hist_abuse = N
            and N = 2
         then ua = yes cf 30.

rule-30: if civ_charges = N
            and N = 1
         then ua = yes cf 40.

rule-31: if fam_prob = N
            and N = 1
         then ua = yes cf 30.

rule-32: if rom_prob = N
            and N = 1
         then ua = yes cf 30.

rule-33: if maturity = N
            and N = 1
         then ua = yes cf -40.

rule-34: if maturity = N
            and N = 3
         then ua = yes cf 50.

rule-35: if esteem = N
            and N = 1
         then ua = yes cf -40.

rule-36: if esteem = N
            and N = 3
         then ua = yes cf 40.

rule-37: if reduction = N
            and N = 1
         then ua = yes cf 40.
```

```
/* ******************************************************
                 QUESTIONS
   ****************************************************** */

question-1: question(rank) = '        What rank does the
            accused hold?

                1. Private
                2. PFC
                3. Lance Corporal
                4. Corporal
                5. Sergeant
                6. Staff Sergeant or above'.
legalvals(rank) = [1, 2, 3, 4, 5, 6].

question-2: question(seriousness) = '        How serious
            are the pending charges?

                1. minor charges
                2. one major charge
                3. multiple major charges
                4. serious charges'.
legalvals(seriousness) = [1, 2, 3, 4].

question-3: question(prior_ua) = '        How many prior
            instances of unauthorized absence can be
            attributed to the accused?

                1. Less than two
                2. Two or more'.
legalvals(prior_ua) = [1, 2].

question-4: question(enlistment) = '        Which enlistment
            is the accused currently serving?

                1. first enlistment
                2. second or greater enlistment'.
legalvals(enlistment) = [1, 2].

question-5: question(age) = '        In what age category
     does the accused fall?

                1. under 21
                2. 21 to 23
                3. over 23'.
legalvals(age) = [1, 2, 3].

question-6: question(gct) = '        In which category
     does the GCT score of the accused fall?
```

```
                1. below 95
                2. 95 to 105
                3. above 105'.
legalvals(gct) = [1, 2, 3].

question-7: question(unit_award) = '        Is the accused
            authorized to wear a unit award ribbon?

                1. Yes
                2. No'.
legalvals(unit_award) = [1, 2].

question-8: question(pos_entry) = '        Does the accused
     have any positive entries on page 11 of
            his service record book?

                1. Yes
                2. No'.
legalvals(pos_entry) = [1, 2].

question-9: question(pending_ua) = '        Do the pending
            charges include unauthorized absence?

                1. Yes
                2. No'.
legalvals(pending_ua) = [1, 2].

question-10: question(apprehended) = '        Was the
      accused apprehended rather than surrendering
      to authorities?

                1. Yes
                2. No'.
legalvals(apprehended) = [1, 2].

question-11: question(reputation) = '        What type of
      reputation for integrity does the accused
      have in the unit?

                1. Excellent
                2. Good
                3. Mixed or uncertain
                4. Poor'.
legalvals(reputation) = [1, 2, 3, 4].

question-12: question(harass_pot) = '        What is the
      potential for harassment in the smallest
      unit where the accused will be working?
```

```
                1. high
                2. moderate
                3. low'.
legalvals(harass_pot) = [1, 2, 3].

question-13: question(hist_abuse) = '        What kind of
      history does the accused have of drug or
      alcohol abuse?

                1. serious abuse
                2. occasional abuse
                3. none'.
legalvals(hist_abuse) = [1, 2, 3].

question-14: question(civ_charges) = '        Is the accused
      charged with civilian as well as military
      offenses?

                1. yes
                2. no'.
legalvals(civ_charges) = [1, 2].

question-15: question(fam_prob) = '        Is the family
      of the accused experiencing problems which
      may influence the accused to flee?

                1. yes
                2. no'.
legalvals(fam_prob) = [1, 2].

question-16: question(rom_prob) = '        Does the accused
      have a romantic relationship which may
      influence him or her to flee?

                1. yes
                2. no'.
legalvals(rom_prob) = [1, 2].

question-17: question(maturity) = '        How might the
             level of maturity of the accused be
             characterized?

                1. high
                2. moderate
                3. low'.
legalvals(maturity) = [1, 2, 3].

question-18: question(esteem) = '        How might the level
      of self esteem of the accused be characterized?
```

```
                1. high
                2. moderate
                3. low'.
legalvals(esteem) = [1, 2, 3].

question-19: question(reduction) = '        Has the accused
      recently been the subject of a punitive
      or administrative reduction in grade?

                1. yes
                2. no'.
legalvals(reduction) = [1, 2].
```

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